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THE STUDY *of* NATURE

BY

SAMUEL CHRISTIAN SCHMUCKER,

A.M., PH.D.

PROFESSOR OF BIOLOGICAL SCIENCES IN THE WEST CHESTER (PENNSYLVANIA) STATE NORMAL SCHOOL

WITH ILLUSTRATIONS BY

KATHARINE ELIZABETH SCHMUCKER

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EDITOR'S PREFACE

The agency by which civilization is rendered progressive is education. Whatever is visioned as a good for the race as a whole, education is to make the possession of the many. In general the great educational agencies of the race are the world-spirit, environment, and the teacher.

The world-spirit is the the influence of Divine Providence upon the human soul. The whole race is at school to this supernatural and potential force. More than we know, this world-spirit educates us. The distinctive quality of this influence may be called "education by atmosphere." Its best results are by indirection. We are prone to underestimate the far-reaching and vitally significant power that lies in the subtle suggestions of "the still small voice," and that thrills the spirit with reverent awe. Communion with the unseen is nutrition of the loftiest character.

Environment is the influence of natural law and social custom moulding man steadily but imperceptibly into the perfect product that is at once the hope and the despair of the idealist. Environment sets all the currents of the soul aflow with streams of influence that, unchecked, lift the individual to his ideal state. There can be no potency in an education that does not give the learner vivid impressions from actual contact with things. The word "bug" can never mean as much educationally as the real bug. In fact, the worth of the former as an educational agency depends upon its following close upon an experience with the latter. Words

name ideas. They do not engender ideas. Things give birth to ideas. Hence one's environment is educationally possessed of the greatest potential worth. It is the business of the school to convert this potential worth into active, usable educational data.

The teacher is the trained individual set by experience to accomplish, by the quickening processes of method and principle, the speediest orderly comprehension in each individual of the richest inheritance of thought that the race has treasured for its legitimate heir, the child. The teacher studies the time element in the educational process. He is conscious of the need for such an elimination of non-vital elements in the data of the school as will bring the learner in the briefest time to the highest mental development and to the possession of a fairly varied and extended field of facts. The teacher also studies the mental complex of each learner, and ascertains how this varies in the several learners and in the several stages of growth in each learner. This knowledge, combined with relatively full understanding of the subject matter to be taught, enables him to bring the learner speedily and surely into his best estate.

Thus Nature, the race's physical environment, becomes one of the great teachers of the child. Its function has not always been understood, and its value has not always been recognized. Children have senses, but they have not been trained to gather from the objects about them that rich and varied nutrition their spirits need and which, if properly aroused, they would constantly crave. We hear much of the out-of-door habit, and such a habit is undeniably desirable, but its attainment is conditioned upon the forces in one's environment to woo the spirit to the secret haunts of birds and flowers.

The early years of training should include the conscious effort to make the learner feel at home with his physical environment, to be on terms of intimate friendliness with the multiform aspects of earth and air and sea and sky. This intimacy established, the future years will but increase the power of subtle suggestions and enrich the life of the wanderer out under tree and sky, by meadow and stream, into the heart of things that teem with suggestion and fill the spirit to overflowing.

The study of nature in school should create a passionate love for the things in God's great school. This can never be done by any formal lessons of an analytical sort. We may analyze flowers and dissect animals in the laboratory; but all this, at its best, cannot set the soul of a child aflame with interest in the objects of his environment. Such study deadens all interest and negatives the essential good the study aims to achieve. "Object Lessons" happily no longer make a farce of nature teaching, and text-books of analytic data concerning the things of nature are likewise finding their resting-place among the dust-covered mementoes of a day that is gone. We now see that information is not nearly so vital as inspiration. The aim is not primarily to cause a child to know, but to love, nature. This love later on in secondary schools and colleges can be organized into all sorts of categories and formulas, but the first approach to nature must be sympathetic, not scientific.

We must teach, and we must allow pupils to love sincerely, and in their own way, the great and wonderful world "that shines so peacefully about us." A child should be led out into nature, set in the midst of loveliness, lost in the wavering morrice of nature's glee,

and allowed to use his heart as a compass to find his way along his own track back into himself, bearing rich reflections and fragrant facts for organization into higher ideals and nobler conduct.

This observation and its attendant reflection must yield expression in clear, concise, correct language, and in such skill of the hand as to portray in a fairly adequate way by line and color the impressions in his mind. It is foolish to use the objects of nature for busy work. It is, likewise, foolish to fret the child with endless questioning. Here freedom of investigation and fulness of reflection are the safest guidance, the sanest method. We must never forget that a child in reflection is struggling and strengthening, and will at last break into adequate expression.

There can be no substitute for a teacher thoroughly infused with nature-lore and nature-love. In addition to a thorough training in descriptive natural history as a preparation for class work, the teacher should frequently spend his holiday time in excursions to the country. Nor should he forget that, with the rest his vacation should afford, it should give him many delicious drafts at the fountains whence spring all the music, color, form and motion in the world without.

> "Wonderful, indeed, is the world of beauty about us,
> More wonderful still is the world of beauty within us."

The wise teacher will steadily strive to translate beautiful things into beautiful thoughts, and beautiful thoughts into beautiful deeds. We will aim to make thought richer and conduct nobler because of the lessons learned so near to nature's heart. We cannot always bring the things of our environment into the school, but we can bring there, in their natural state, such type

objects for study as to make vastly significant all subsequent experience. This is no serious limitation, for the school is at best but an experience for the pupil in typical things. The full, rich, varied fields of thought in every department of study lie beyond the horizon of the school. The function of the school is to train the growing spirit, through types, to entertain the fuller vision afforded by subsequent experience.

These typical objects, when used in school, must be placed with the pupils by a teacher whose spirit is suffused with interest in the object. The interest of the teacher is the magic power that enkindles enthusiasm in the pupils. To present one object thoroughly and well, with a maximum of enthusiasm, is worth many, many aimless and desultory exercises. The mere fact that the object itself has elements of potential interest is not enough. A class may languish in the presence of the most interesting things if the teacher have not the fine insight and genuine interest which alone lift the learner to the plane upon which instruction is easy and acquisition a delight. It is the life of the teacher in the recitation that arouses a lively interest in the learner.

The author of this volume, with rare insight and skill, has here given to teachers in orderly array such typical exercises and such appreciative interpretation of the things in our common environment as to make delightful the interpreting of nature to a child. He has the rare combination of scientific method and mastery and a spirit so reverent and stimulating as to make him easily master of the best methods of nature teaching known to our latest experience. His printed pages will be as informing and as inspiriting as have been his addresses to teachers throughout the country.

M. G. B.

March 24, 1908.

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THE STUDY OF NATURE

SECTION I—THE THEORY

I

WHAT NATURE STUDY IS

1. NATURE STUDY is the study of nature. Whenever the teacher has any question in his mind as to whether his work in nature study is good or not he need only ask himself, Have I been studying nature or have I been studying about nature?

Test of Nature Study.

2. The free open air is the best background for all work in nature study. The conventionalities of the school-room fall away. The artificial distance between teacher and pupil disappears, and as friend to friend the group talks. It is this that makes work in nature study at its best so delightful. So long as the group is not too large, and the weather is favorable, no other lessons bring so large a return as those given out of doors. The wealth of material is very great, and the suggestions that come from things in their proper places are much more abounding than those that arise in the artificial conditions of the school-room. The teacher who tries to do nature work in the school-room, and occasionally manages to take a class out of doors, realizes how valuable such work is. Few teachers who have tried it are willing to relinquish it

Work out of Doors.

4

3. The pupils look upon such days as red-letter days in their calendars. There are many schools in which the out-door lessons cannot be frequent. This, however, is not so largely the case as might be expected. Certain it is, in every rural school much can be done by the skilful teacher in the way of out-door work. If the whole school takes part in the exercises, there is no difficulty whatever. Where only a part of the pupils share in the work at any one time, leaving the school-room becomes a less simple problem; and yet the teacher has poor control over a school who cannot take a group of pupils out upon the grounds within a short distance of the building and have his presence sufficiently felt in the school-room to maintain entire order. The school-room is not well in hand which cannot be left to manage itself at least for a short time without confusion. There are conditions under which very little outside work can be done; however, with care, the loss is not so great as one might expect. Out-of-door life can be brought within doors and with it can be brought very much of its interest. A live animal in the school-room is in itself a source of interest. The teacher who is disconcerted by the advent of a stray dog and who does not turn the incident to educational advantage, is missing a distinct opportunity. When the teacher can welcome the dog, and can make him contribute his share of instruction, he can make of the familiar creature a centre of interest and make his intrusion seem welcome.

Substitutes for Out-door Work.

Whenever a live animal is deliberately brought into the school-room for the actual purpose of nature study, the best results can only be secured if its surroundings are brought with it. Of course, a fish should be studied in water, but this is only the beginning of the best work.

The plants in the aquarium should be, if possible, the plants of the water which this fish ordinarily haunts, and the bottom of the aquarium should be made of the same sort of material as the bottom of the stream. This may not be always entirely practicable, but just so far as it is, it is evident that it is valuable. The turtle which is brought into the school-room should not simply be kept in a box, but should have the sort of ground over which he has been accustomed to roam, and should be provided with the food which he would meet outside.

4. In the case of plants, the entire growing plant is far more interesting, where it is possible to have it, than are pieces of plants. If wild flowers are to be studied, the taking up of a little soil and moss with the plant, the using of it in the school-room, and then the planting of the same plant in the wild garden of the school, are valuable in very many ways. This must not degenerate into the reckless destruction of large numbers of wild plants. This would be paying too large a price. But if a choice plant be carefully lifted, earnestly studied in the school-room, and then planted somewhere on the school grounds, in a situation as nearly like the one from which it came as it is possible to find, the lesson will be a good one. In this way there will grow up about the school grounds, a school garden which will claim the care of the pupils, even though there be no set lessons in school gardening. By this means, a later year may have its lessons in the school grounds, because the material is now close at hand. The arbutus, hepatica, and bloodroot, that grow up beside the wall, the azalea or rhododendron and laurel, which grow along the fence, will serve as a beginning which cannot but end in vastly more beautiful school grounds.

The Use of Plants.

5. But even should the nature teacher not believe

himself able either to take his classes out of doors or to imitate the out-door work in-doors, it none the less remains true that nature work is not nature work unless it be done from the actual material. This is the absolutely irreducible basis of all effective work. Without it, there may be lessons that contain useful information, there may be lessons that inspire the lagging interest of the pupils, there may be lessons that inculcate sound ethics, but none the less they are not lessons in nature study. Nature study is the study of nature, and nothing else is effective until it has found its clear and distinct foundation in some piece of actual first-hand observation. It is easy to have interest without such material if the teacher has interest; it is easy to impart information that may be more or less valuable; but to gain those clear and definite aims which nature study starts out to secure, nothing will serve but the actual, close-at-hand observation on the part of the pupil himself. Hence it is one of the first objects of every successful nature teacher to gather a very considerable amount of material available for this work. The nest of the mud-wasp, chestnuts in the burr, galls upon plant stems, burrs of all kinds, shells where-ever they may be picked up,—indeed almost any object that can be gathered out of doors, and that can by any means be made to contribute interest to the work, should be taken whenever found, and on such material as a foundation the work should always be based. When-ever a subject has been well treated, in some such fashion as this, there may follow later any amount of illustration, of widening and enrichment, provided it flows naturally out of the material examined. But it will be subversive of the entire purpose of nature study, if a small amount of attention to a familiar object is simply

The Need of Actual Materials.

made the excuse for a large amount of work that is properly literature, or science, or geography, and is not nature study.

6. The teacher who begins nature work cannot realize too clearly that the materials for nature study should be chosen for their abundance rather than for their rarity. A chestnut burr with its chestnuts is more interesting to the pupil, and, in the earlier years of school life, more valuable for purposes of nature study in every way, than is the sprig of coral broken from a Florida or Bermuda reef, although these conditions would be exactly reversed were the nature-study lesson being taught in the Bermudas. The pupil who, in studying a familiar object, has first contributed to the general store a little information of his own, is in a better frame of mind to enjoy and to comprehend additional points of interest on the subject he is studying. The great value of the lesson is tied up in the fact that all through his later life he will constantly be brought face to face with this same familiar object, and he will never pass the object without, perhaps quite unconsciously, enriching his notice of it by what he learned as a boy. This, often repeated, make one's environment a constant stimulus. It fills the objects of one's daily life with a perennial interest. The man who lives in surroundings which are interesting and stimulating has exactly the same advantage over a man not so interested as he who is encircled by friends has over one who is friendless amidst crowds.

Common Things are Best.

7. The constant temptation of the nature teacher, and one to which he often unfortunately succumbs, is to substitute a picture of the thing for the thing itself. If nature study is the study of nature, then certainly the study of pictures is not nature study. I do not

mean by this, that pictures do not have a place, and a very valuable place, in the work in nature study. When they can be made to explain, to enrich, to beautify, a subject which has already had its good basis of actual observation, they are valuable. There is one practical use to which pictures can be constantly put, and that is, to produce in the mind of a pupil a preparedness for observation. If the teacher means that the pupils should learn to know the meadow-lark, then a picture of a meadow-lark will serve to help them understand what it is they are to see. In this sense it serves as a crutch to one who is learning to walk, but it must be soon replaced by the object itself. If the bird itself has once been recognized, all questions concerning it should be questions that must be answered from the bird itself, or from its natural surroundings, and not from the picture which has now finished its main usefulness.

Pictures are a Weak Substitute.

8. If the temptation to work from pictures is great, the temptation to work from books is still greater. We have been so long accustomed to deriving our information from books, that it scarcely seems possible to obtain it in any other way. If nature study is to do its proper work in the school-room, there are few things that it can teach of greater value to the average pupil than that he has the power of himself to gather his own information. Accurate information gained from a book is more valuable than slipshod information taken from personal observation. But when once the pupil has formed the habit of gathering information at first hand, there is a joy in its acquisition, and a clearness in the result, which make such information a far more lasting part of one's general store than is information gathered from a book.

Objects are Better than Books.

9. There are so many branches in the curriculum in which the information is gathered from the printed page, that nature study would be of doubtful value if it but added to this number. There is so little work in the school-room which depends upon the pupil's own effort that this is highly necessary as a part of school training. To leave it to the teaching of experience outside of school means to send the child into life only half equipped.

The Relief from Book Work.

10. Although the study of books is not nature study, and never can be, and although it should under no circumstances be allowed to usurp the place of direct observation, it would be folly to disregard the high value of books, and to thus set aside the experience of the past. To launch oneself into the world as if man had never thought before, and never before turned his eye to nature, would be to forfeit the privileges of being a human being, and to lose the advantage of a long civilization. Hence, books must play a very important part, but the part must be clearly defined. They must not take the place of observation; they must not lessen observation; they must increase both the number and the richness of the observations. Information is so quickly gathered from the book, and so slowly gathered by direct observation, that there is an apparent saving of time by taking facts directly from the book, but if these facts are not originally observed, or subsequently verified, they will lack both the vividness and the permanency of those ideas gained by original observation.

Books Guide Observation.

The teacher who is new to the work will undoubtedly be helped by the use of such guides as aid him to determine what objects had best be studied at a definite time. There are many practical books which will help

a teacher to find the material that he needs for his work. They will suggest sufficiently the thing that is worth observing. To have read any of our better bird-writers, for instance, on the subject of any particular bird, cannot fail to make the teacher more observant of the bird, and if he will but verify these observations in the field, there will be no question of the great value of this book in his work. But if he gathers his information from a book and then fails to make it his own by actually seeing it in the field, he will lose much of his power to interest, and will fail to make of his pupils accurate observers of bird life. There is another possible value in a book, and that is found when it serves in assisting the teacher to identify material which he has found. A new flower is brought in by a pupil and the teacher does not know it. If he be botanist enough to use a key this will give him the desired name, with perhaps some little information concerning the structure of the plant. It is far more likely that the identification of the plant by means of one of the modern popular nature books on flowers will yield him return distinctly more valuable for his particular purpose than the more strictly scientific treatise. I hope it is needless to remark that the teacher should never mention to elementary pupils the Latin name of a plant or animal. Such names are indispensable in their place, but their place is not in the work of an elementary teacher.

11. Far more valuable than these books of information, are the works of those men whose broad conception of nature allows us to step from our own observation in our own surroundings out into the great world. To one who knows his own home well, the pages of such a book are fairly illuminating. The world away from home takes on a new appearance, built up out of con-

ceptions gained at first hand in one's own neighborhood. Even of double value are the writings of those seers whose hearts have lain close to Nature's heart and have learned to beat in unison with hers. It matters little here that our poets often make technical mistakes in science. No student of the nautilus will ever do more for the sensitive reader than will Holmes's poem. Shelley's "Ode to the Skylark" will give greater enjoyment than any technical description of the bird could ever give, and to have laughed with Wordworth's "daffodils" is worth more than to be acquainted with the fact that these same daffodils are members of the *Amaryllidaceæ.* None the less no one gets the full value of either poem who has not seen the shell of a chambered nautilus and does not understand its life; who has not watched a bird in "ecstatic" flight; who has not learned to appreciate the place in nature, independent of man, of the gorgeous color of a patch of daffodils.

Books Bring Inspiration.

12. We have, then, one sharp criterion by which to judge the value of a book for purposes of nature study. If it leads us to nature, if it sends us out into the open, if it makes us clearer in our observation and more earnest in our search, it is a good book. On the other hand, if it makes us content to study nature by the fireside and in the library, then it may be charming literature, but it is not nature study.

The Test of Nature Books.

II

THE GENERAL AIM OF NATURE STUDY

13. ANY teacher who intends to do good work in nature study will need to have clearly before him some aim which he is to accomplish. In most of the ordinary subjects of the school course, the text-book practically settles for the teacher the direction and the trend of the work, but in nature study this is not the case.

The Need of an Aim.

14. Every one recognizes how constantly things fall beneath our eyes without attracting our attention, and it was to correct this difficulty that nature study, or rather its forerunner, the object lesson, first found its place in the school work. This aim of training the senses, particularly the sense of sight, was practically the only aim. Our understanding of the pedagogy of nature study has now gone far past this line, but we must never forget that careful observation lies at the foundation of all nature work, and until we do secure good observation none of our other results can be safely counted upon as likely to follow.

Careful Observation is Needed.

15. That many people fail to see the things which they would naturally be expected to see is a matter of common remark, but I think most of us fail to recognize how entirely this is true even of people who have been fond of such lines as ought to make them good observers. I have long since ceased to be surprised when I find something new that I should have found years before. An instance from my own experience may not prove amiss. The

Observation is Commonly Poor.

modern student of any group of animals has given up the thought of familiarizing himself with all the members of the group. He has come to be content with one of two methods of procedure; either he will take a small group and study it intensely, or he will take a larger group and content himself with a familiarity with what are known as typical examples. This was Huxley's method, and is a favorite method with the modern scientist who does not aim to be a specialist in any particular group of animals.

In studying insects, my curiosity was aroused by and my attention attracted to the description of a bug in Comstock's excellent "Manual for the Study of Insects." In describing the creature Comstock says that it is "clothed from head to foot in fine white Brussels net." My desire to see the insect was intensified by the beauty of the picture which Mrs. Comstock had made to illustrate this species. But I had studied insects many years before I came across my first lace-bug, in the hands of a friend. When I asked the owner of it where it could be found, and he replied, "Almost anywhere," I felt that the information was too vague. When I narrowed him down, he confessed he usually found it under the bark of trees, and upon urging him to be still more specific, he mentioned sycamore trees. My heart sank, for what child has not repeatedly peeled the bark from the sycamore trees? My mind went back to two which had stood before my grandfather's house. As a child, I had broken its bark into the shape of coins to use in the children's game of store-keeping. Later I had lived for five years under the shadow of a sycamore, and had then already more or less fondness for insects. It seemed impossible that this creature could be abundant and I should not have noticed it. That evening,

however, I chanced to pass a row of sycamores, and taking out my knife I raised a piece of bark. Imagine my surprise and delight when the first piece of bark yielded thirteen lace-bugs! Since this time I have lifted the bark from very many sycamore trees. Nine times out of ten, summer or winter, persistent search will bring at least an odd specimen or two from any such tree.

16. Of course, no amount of training improves the eyesight. The image on the retina of a child, unless the child's eyes are distinctly defective, is probably clearer than it ever will be later in life, and any improvement on its sharpness will be almost certainly due to the use of glasses. Of the images which are formed upon our retina, very few, indeed, are recognized by the brain. So it is that the training which is to improve the observation is the training of the brain back of the eye, and not at all of the eye itself. The things which we recognize are commonly familiar things, though it may often happen that when they once get too familiar we again fail to notice them, and nothing but a change in our surroundings and the absence of a familiar object excites our attention. But into this general field of observation, of which we are only half conscious, clear spots of sharp vision intrude themselves. We notice, perhaps most of all, things to which we have recently had our attention drawn by some circumstance and are now re-seeing. For most of us these form the main objects of our interested attention. Those which come to be associated with the necessary routine of daily life also come to be quickly and quite automatically noticed. The farmer, passing through the corn, notices a smutted stalk or a broken fence-rail, provided he is good farmer enough to act whenever he sees such a state of

What do We See?

affairs. The librarian notices quite unconsciously a book out of its proper place, although he may not have been intending to straighten out the collection.

But there is one class of objects to which we pay attention with uncommon interest. These are the objects to which our interested attention has been called but which we have not yet seen. The delight with which the boy first sees a bird concerning which his appetite has been whetted, is most vivid, and the hunter who flushes his first grouse has a keenness of sensation which he will be long in duplicating. The way, then, to make the child observant is, in the first place, to keep him hungry for definite things which are likely soon to turn up; and then, too, to teach him new facts concerning things he has often noticed before. The boy or girl well provided in these two respects is sure of a joyous out-door life.

17. The second great conscious aim in the pursuit of nature study, and this is the aim which converted the object lesson into nature study, is the acquisition of a store of valuable information. Within the last twenty-five years the whole trend of modern study has been transformed. The historian, the essayist, the student of the literature of the past, still have a place, and an honorable place, in modern life, but it is the second place. The first place has been yielded to the engineer, the scientist, and the captain of industry. It is the development of modern science which has brought about this result. Work, carried on previously by rules of thumb, which are the result of individual experience, handed down as a trade secret, is now given clearness and precision by being laid out by the engineer and controlled by the chemist, in accordance with knowledge gained in the laboratory.

The Result on the Study of Geography.

There arose, hence, a rapid increase in the esteem in which scientific knowledge was held, and the scientist, instead of being the butt for the jokes in the humorous papers, has become the main-spring in the development of modern industry. It is most natural that, under such circumstances, teachers who realize how short is the school life of many of our children should be filled with an eager desire to give to these children, before they leave school, at least an introduction to the general principles of science. Therefore the object study became what was then called elementary science. To further this aim, the teaching world asked the scientist to put into easy language the principles of his science. He usually succeeded in making the words simple, but the ideas themselves were the last flower of scientific study and were, for the most part, entirely beyond the comprehension of anybody below the grade of high-school students.

Professor L. H. Bailey has struck the proper key-note in this matter. He says, that when you are thinking of the subject you are studying, you are studying science, but when you are thinking of the child, you are studying nature study. The simple facts of nature round about are at first the only things for the child; later will succeed the simpler reasons for things, while only late and matured thought will cope to advantage with the deep and underlying general principles. It is clear, then, that the careful teacher of nature study must see to it that his pupils gain the power of clear perception of objects round about them. It is equally clear that the wise teacher will choose such objects in the immediate environment as are in themselves interesting and which at the same time science has shown to be worth the knowing. Having secured these two points

we have done much, but we have only begun our work, and will never secure what every teacher ought to secure unless we make them strengthen and support the other work that is being done in the school-room.

The study of geography is being re-created in recent years. To the good modern student of geography, the hills rise in evident relief, the waters tumble down the hill-side, the plains wave with wheat or corn, while through the valleys pass the lines of railroad, and the sea is covered with vessels carrying the product of every clime to every other. Such work as this is utterly impossible unless the pupil has formed in his early years a clear series of primary ideas on which to build. The pupil who has gone with the teacher to the road-side after a shower has been led to notice how the rain has worn the gutter, has noticed how the stone in the gutter has produced a water-fall beneath it, and has seen how the top of the gully just made by the last rain is clear and sharp on its edges, while the places farther down, worn by many rains, have wide valleys and rounded edges. Such a pupil is prepared to understand the great work which the rivers have done in carving the face of the earth. He decides as he looks across the valley in which he lives whether or not this valley is a new valley, whether nature is still deepening it or has taken to widening it. The boy who has seen the pond fill up with material brought in by the stream is prepared to understand, as he never did before, the meaning of the great deltas of the world. The pupil has looked at a stalk of corn; has noticed the knots in its stem above each of which the stem may grow and lengthen; has seen the leaves which offer so little resistance to the wind; has brushed from his coat the pollen from the tassel. Now he is prepared to understand the

life of any grass wherever it may grow, and is also, if properly guided, prepared to understand why the plains of the world are usually covered with grass; is prepared to build up in his mind a prairie, a pampas, or a llano.

Nature Study and the Work in Language.

18. By the selection of such subjects as these the teacher will gain not only clearness of observation on the part of the child, and scientific information valuable for itself, but will at the same time be making it possible for other branches in the course of study to take on such vitality as was not heretofore possible. There is one place, at least, at which the nature study should continually touch the other work of the school-room, and this is in the study of language. Clearness of perception is the first factor in the production of terse and vigorous expression, and each of these will react upon the other. The man of vigorous language will be on the constant lookout, though quite unconsciously perhaps, for new impressions, and these will take clear-cut form in his mind. So dulness and lack of interest in the construction of a sentence in language is often due to the fact that the thought itself is absolutely without interest. There are few children who cannot talk reasonably well on a subject which distinctly interests them, unless their attempt to do so has been repeatedly quenched by the teacher, who was so careful of the form as to miss the value of the content and the spirit. If the teacher, then, wishes to have good spoken and written language, his first attention should be paid to allowing the child to gain a clear idea from a natural object.

19. These four aims, then, every good teacher of nature study should keep clearly before himself, and not count himself satisfied with his work until he feels he has made definite progress in each of these direc-

tions. Let him say for himself, "I must have a familiar object to teach, and must get the children to see it clearly from many sides. I must see to it that I am not frittering away the time of the child on facts not worth the knowing. The information must not only be valuable, it must help to strengthen and bind together the work in other directions. Finally, it must lead to good, vigorous, expressive language, which shall be distinctly colored if possible by the individuality of the child. When I have secured this, and not until then, have I done what may be reasonably counted my duty, if I am to do nature work at all."

Four Aims of Nature Study.

III

THE REAL PURPOSE OF NATURE STUDY

20. The preceding chapter states the formal and definite aims which every teacher of nature study should keep distinctly in view, and the attainment of which we may reasonably expect in a fair degree from every good teacher of the subject. But there are other teachers,—teachers to whom teaching is more than an occupation, teachers to whom the school-room is an opportunity, and every child the object of an earnest desire on the part of the teacher. These are the teachers whose hearts have been filled with the modern idea of social service; the teachers who feel that their work is part of the great work of making the world a better place in which men and women may live. To a teacher of this sort, nature study with its greater freedom of contact between the teacher and the pupil, with its great possibility of individuality on the part of the pupil, offers a more than commonly good field for work, and it is to this teacher particularly that I wish to speak in this chapter.

The Higher Possibilities of Nature Study.

21. There are two very distinctive aspects of the life of every man or woman. One of these is the immediate practical side by which that man or woman makes his or her way in life. This properly occupies a large proportion of time and energy. The man is unfortunate who does not take a keen interest in his work; none the less, the truth remains that much of the enjoyment of life lies outside of his daily round of existence. The modern man has come to know that if

Our Need of Culture.

he is to work effectively, he must not be rigidly bound to his work. Recreation and vacation have become the essential parts of a natural basis of man's existence; but this is only the case when he has come to realize that recreation is valuable, not in any sense for itself, but because it serves as a refreshing and strengthening for the work which is before him. This recreation should quite as thoroughly be recreation of the mind as of the body, and the man's life lacks roundness who fails to give a reasonable part of his time to the intangible but no less desirable something which men call culture. After the ties of family life and of religion, there is nothing else that adds so much to the joy of life as this same intangible culture.

The Value of the Arts.

22. The form which culture may take will vary with different people. To one the literature of the past forms the great body of his recreative mental enjoyment. To live again the lives of men, to strengthen his life with their strength, or to guard his life from their weaknesses, is to many a man one of the most potent forces in his spiritual building. To another the music of beautiful words is his greatest enjoyment, and the life that may have in it much of toil and strenuous endeavor may none the less have its moments of delightful peace with the singers of the past. To another, the charm of painting, with all its power to bring up beauty in the mind, will form the greatest source of intellectual delight. One who is privileged to see frequently the works of great masters, who has opportunity to saturate himself with their high ideals, finds in art the most potent factor in sweetening life. To rejoice in the gorgeous coloring of a Titian, or a Rubens, or a Turner; to discern the exquisite delicacy of a Meissonier, or of a Delacroix; to feel the quiet mystic power of a Hunt or a

Rossetti,—to vibrate under the influence of these masters is to find for oneself one of the most potent forms which culture can take. To many to whom literature has comparatively few charms, and to whom the picture without a story has practically no meaning, music may appeal powerfully. Blessed is the mortal who has learned to feel the triple appeal of literature, art, and music. If he have a life-work which demands his active energy and upon which he depends for a living, has a family with whom he can share his troubles and his joys, and adds to all of this a love of literature, a feeling for art, and a fondness for music, he has reached nearly the acme of human advancement.

The Arts Reach too Few People.

23. But all that this implies is almost of necessity a closed book to a large proportion of the population of our country. The intensely rapid growth of our land in manufactures and in commerce has drawn to this country an influx of people so enormous as to need our earnest and thoughtful care lest we should foster in our midst the growth of an alien, submerged class, from whom the native population should be separated by a gap more than commonly difficult to bridge. An aristocracy of blood is being constantly recruited of necessity. The barrier of wealth is never impassable, because wealth may come to any one. But when once our population becomes so divided as to form itself into the cultured and the uncultured, into those to whom life shall be filled with meaning and to those to whom life is a continual grind, the line of demarcation is a terrible barrier. The children of our great manufacturing neighborhoods can spend in school life only a very few years. Every effort of the teacher and town officer and factory inspector must stand between them and an entrance into

gainful occupation long before their childish forms have taken their physical set. When we add to this the fact that a foreign tongue makes it absolutely necessary that much of the time should be spent in teaching them the merest rudiments of the English language, and in giving them such small amount of power to compute as will serve the simplest practice of every-day life, it is easy to see that such knowledge of literature, such appreciation of pictures, such love of music, can scarcely be dreamed of. Adding to this the conditions under which most of them must subsequently live, and the absence in many instances of all the facilities for continuing such culture when once begun, we have a state of affairs which makes the possibility of developing such enjoyment in life almost hopeless except for the gifted few who always spring up in every social stratum. If culture is to come into these lives it must come by an entirely different path.

Nature may Foster Culture.

24. Even for the more favored population of our rural communities, to whom the means of gratifying the taste for literature is by no means absent, the time given to school is often so short and so interrupted by the pressure of agricultural occupation that there grows up in many people a lack of love for things which might, if once acquired, make their life almost ideal. The dweller on the farm who has learned to make the farm support him, has learned to find joy in a few good books, and pleasure in a few well-chosen reproductions of good pictures, has attained a development which is almost denied to the great majority of dwellers of the large cities. If we wish to see how the average dwellers of the cities miss all the culture which might be brought into their lives, it needs only that one should visit any of the great popular summer

resorts. It is to these that the solid back-bone of our population goes in the summer time. These people, who are absolutely free from want and yet who are dependent upon their daily labor for their support, form the basis of all that is most stable and valuable in our population. They do the work of the world, and from them, as from a perennial spring, rise the leaders who shall direct the course of events in our country. But to see them crowd in hordes to our popular resorts and rejoice in the hurdy-gurdy, the merry-go-round and the flip-flop, is to realize how much of genuine pleasure, which they would really enjoy, and which would leave them better prepared for the work they have to do when a vacation closes, they might have if they would.

So whether it be for the members of our foreign population who begin life, as a rule, desperately poor, for our rural population who fail to make the most of that which they might have, or for those people who, under the stimulus and excitement of crowds, live an artificial life, there is great need of that sort of quiet enjoyment in life which we have come to know under the general name of culture. It seems to me that there is too little time to accomplish much in literature, music, or art, not so much because the elements of these might not be introduced, as that there is in the subsequent lives of these people too little opportunity for continuing the work begun in school. And yet we may gain new hope from the careful study of nature. The child who, during the few years that he has been in school, has been meeting constantly in his work the objects in nature round about him; who has made them the subject of frequent study; who has gathered around each object a distinct body of information which is of interest to him, cannot fail, if he have been rightly led, to see nature with

a new and keen eye. From her, excepting in the heart of our great cities, he never can escape. She is about him always. His toil may, and his leisure must, bring him face to face with the rocks and trees, the birds and insects, the flowers and the fruits, the clouds and the rain, the moon and the stars; from their presence he cannot escape if he would. Books he may lack the means or disposition to buy; good pictures he may never see; music, beyond that of ragtime, may make little appeal to him; but the landscape is ever with him, and if he have learned in his early life to know and love, to take interest in, and to care for, his surroundings, then he will have a source of possible culture that will stay with him, without undue effort and without cost, for the rest of his life. That acquaintance with nature, a sympathetic acquaintance at least, makes for culture no one can doubt who has in the circle of his acquaintance any genuine nature lover.

Nature is Open to the Poor.

25. It is certainly a worthy hope that at some time or other all the children of our beloved Republic shall have planted in their breasts such a love of the land in which they live, such an appreciation of the beauty of the world in which God has placed them, such an intense sympathy with the land of their birth or of their adoption, as will help to brighten and cheer lives which the daily round of heavy labor, and the absence of large pecuniary returns are likely to render, in the majority of cases, peculiarly barren.

26. Beautiful, however, as is the effect of culture upon life, it is a strange fact that somehow culture does not necessarily make for character. It is quite possible to find men whose lives are saturated with culture, and yet who are absolutely without force. High culture

ought not to be incompatible with strong character. But the two are so often disassociated as to make it seem likely that, under the average human conditions, an excessive attention to either one is apt to result in a distinct deficiency in the other. In this respect, nature is a form of culture which has a distinct advantage. Mr. Huxley has taught us that three things are clearly necessary to the attainment of what is known as the scientific habit. The good scientist must observe clearly, describe accurately, and infer justly. Nothing could be more conducive to the formation of good character than a continuous practice in these matters. Of course, these three scientific requirements can be held to only in their absolute and full meaning in the laboratory, and with pupils of reasonably matured minds. But the pupil of any age may be taught to keep his eyes wide open, and to tell only what he sees, and he need not be very old before he can begin to make reasonable inferences from what he has seen.

The Value of Exactness.

The whole trend of modern practical psychology as it touches the subject of the will, insists that the building up of character is the result of the great sum of the daily activities of life. No amount of good precept produces any lasting effect unless there shall be constant occasion for the exercise in the ordinary avenues of life, of the virtues inculcated. And so it is that much better than lessons on truthfulness is the constant habit of conscious attention to telling the truth in the great body of small matters in which there is no practical temptation to tell anything else. The child who is careful to state the exact number of stamens in the flower, the number of joints in the leg of a beetle, the hour of the day, the position of the thermometer, and

any other fact which admits of accurate statement, is cultivating in himself a practice of truth which will not be likely to fail him when the temptation arises from self interest to state something else. Equally sure is it that the child who is constantly permitted to make slip-shod statements concerning all the little matters in which the information is really indifferent, is at the same time being prepared to have no practical regard for accuracy of statements in the great affairs of life. The teacher who has come to the consciousness that he is teaching, not subjects, but boys and girls, and that the choicest product of his work is not information but character, will find in the nature work material which he can enthusiastically use for the upbuilding of moral force in his pupils. And so it is that nature study may serve in the hands of the really strong teacher not only to make for culture in the life of the pupil, but to do that more important thing, to uplift the moral life.

27. The faithful teacher, to whom his work is a vocation, may find in nature one more avenue for magnificent influence upon the life of the pupil. The spirit of investigation which the scientist has turned loose upon the world, has within the last fifty years been advanced in every conceivable direction. Gradually searchers after truth have learned that the method of the scientist is available in the search for truth of all forms. The time has come when the Bible, which has so long stood in a place by itself, has had turned upon it the searchlight of modern scientific investigation. The result was, at first, to those who love the ancient doctrines, disconcerting, if not bewildering. The very foundations of our faith seemed rocking and liable to be knocked from under our feet. Of course, it was a mistake. No truth can hurt. What

Nature Discloses God.

was disturbed was not the revelation of God, but the form which the revelation had taken in the minds of men in the course of the centuries. There is no danger and there need be no fear that the Bible can suffer from earnest, zealous investigation. But it would be idle to blind ourselves to the fact that many of our old conceptions are being rudely shaken, and that many of our ancient beliefs are to be forever shattered. To those of us who have faith in God, and in methods of investigation, there is no fear but that the outcome will be a higher conception of God and a clearer reverence for investigation. But meanwhile the intermediate stages are most unsettling to many minds, and there is in many quarters a fear that reverence for the Bible and a belief in its power to lead into the higher life are passing away. During this period of unrest, everything that makes for the higher life is of infinite value.

We have had three very distinct stages in our belief as to the relation between God and His creation. The primitive belief based on the literal acceptance of the early chapters of the book of Genesis, has for ages seemed to teach men that at one definite time and with a clear and precise plan, the Creator, acting much as men would have acted, set down upon the earth, in full form, the creatures which were to inhabit it. What there was of deepest value in this idea, men have always derived from it, and now still derive: that there is a Creator of the universe; that He is interested in His creation; that He loves and cares for it. Then came, in the latter half of the past century, an abiding sense of the existence of law, linking event to event and cause with effect; never content with an effect until men had found its cause, and always confident that a cause adequate to the effect was there, even though it had not

been found. Science taught that time was inconceivably long and the earth extremely old, that creatures other than those now inhabiting the earth have run their course and have passed away, their places being taken, not by a new creation, but by their own transformed descendants. Earnest religious men, who were saturated with a belief that no interpretation of God's revelation was possible excepting that of a direct creation, shuddered at the new belief and felt that the powers of darkness were battling with the light. In the minds of multitudes of great scientists there sprang up a hostility to religion which in real truth was not after all a hostility to religion but only hostility to the form which religion then took. Under these circumstances there arose a school of so-called materialists to whom the earth was a great complex, self-contained and self-determined, relentlessly grinding out its own future. But materialism died with the last century. The great scientists of the new century are to a very large degree intense spiritualists. God in now recognized in His universe as never before. No longer is He the Creator who in the distant past created a world from which He now stands aloof, excepting as He sees it to need His interference. Now God is everywhere; now God is in everything. Whatsoever things are beautiful, whatsoever things are true, whatsoever things are of good report, these all are saturated with divinity. Man is no longer, in his outward form, the image of his maker; but in every good impulse, every righteous longing, every earnest endeavor, shines forth the indwelling God. God is no longer simply the ruler over the world; God is everywhere in the world.

> "Earth's crammed with Heaven
> And every common bush afire with God;
> But only he who knows takes off his shoes."

28. In many parts of our country the religious conditions make it impossible that the Bible or religion as such should be spoken of in the school. A variety of religious beliefs, every one of which must command our entire respect, will, in many sections having a mixed population, make religious exercises entirely inadmissable. But the teacher who is himself filled with holy zeal, who has himself learned to find in nature the temple of the living God, can without offence to Catholic or Protestant, to Jew or Gentile, bring his pupils into the temple and make them feel the presence there of the great immanent God.

Where the Bible is Excluded.

29. Many there are who will say that the three purposes which are held before the teacher in this chapter are intangible and illusory; that they may be full of pious aspiration but that they lack practicability. But there will be a body, perhaps small, but made up of intensely effective teachers, to whom every aim I have mentioned will appeal. They will feel these purposes,—the enrichment of life, the establishment of firm character and a reverent attitude towards the great Power about us,—are the highest attainments which school life can bring. Such teachers will agree that the study of nature can serve as a powerful aid to the accomplishment of these aims without sacrificing one minute of the time or of the effort which should go to the practical realization of the ordinary aims of school life.

Three High Aims.

IV

THE TEACHER'S PREPARATION

30. THE greatest obstacle to the prompt introduction of nature study into our schools lies in the lack of preparation on the part of the teachers. Very few of them, indeed, have had preparation directly intended to assist them in doing this work, and if we have to wait until our teachers have, as a body, been instructed in the pedagogy of nature study, the time would probably never come when this subject would find its place in our curriculum. But nature study is not a new subject; it is simply a new aspect of old subjects, a new spirit breathed into old work; not necessarily even with a place in the program, and certainly not usurping the place of anything else. Therefore, preparation on the part of the teacher consists not so much in learning new principles, and new facts, as in applying old principles and old facts in a new direction. The zealous teacher who really wishes to do nature-study work, while he of course would derive advantage from a course on this subject, whether taken at the normal school, a summer school, a Chautauqua, or a university, need not despair if none of these opportunities be open to him. It is quite possible for him, under the care and guidance of a reasonably good book, to make of himself gradually a good student of nature; and a good teacher of nature study can find much of joy and much of health while the process is going on. If the teacher have studied both botany and zoölogy, he has a splendid foundation for the work. If to this

Self-teaching is Possible.

he have added a course in geography or physiography he has a still better equipment. Best of all will it be if he have such mastery of them that he can think them in his own language, forgetful at such times absolutely of the technical science, and yet able to use these terms whenever, for purposes for his own information, he desires to consult the more technical authority. With such a basis as this, the teacher has everything to hope and nothing to fear.

Now let the teacher step out into the open air and realize that as soon as he is there he is face to face with nature. He will not need to take a two-mile walk in order that at the end of it he may find nature. She greets him as soon as he goes out of doors, and the tree in front of the house, the grass about the step, is already a fruitful field. If he were to go no farther, he would find here abundant material. It will not be hard for him to find out what sort of tree it is which grows before his door, and I know no better place for the student-teacher to begin than by knowing the name of every kind of tree that grows between his home and the school. This is a matter so easy of attainment, providing one has the proper reference books, that there is no excuse for not knowing it if one wishes to do so. Even though one may not have access to such a book, there is usually in every locality somebody who knows the trees well enough to give him the names of those most common.

It would be more than could be expected of most nature students that the teacher should know the grasses as he knows the trees, though a few of the commoner grasses might easily be learned. But it takes very little observation to see that the grass growing in one place is by no means the grass growing in another location. Very little grass grows under the trees, and such as does

grow there is ordinarily quite different from that which grows in the open sun. Why have we come to plant grass on our lawns? What is there about grass that makes it desirable for lawns? Why is it that constant mowing the grass improves rather than injures a lawn? All these are questions which the inquiring student may very naturally and properly ask himself and hope that an answer will be eventually forthcoming. If he can answer the question to himself with what seems to him a reasonable and convincing answer, he will probably remember it longer and make it a more connected part of his mental furniture than if he had gotten it from the pages of a text-book in botany.

Familiar Objects are the Best.

31. I have dwelt upon these problems just outside of the door because I want the student of nature to feel how absolutely he is face to face with his problem all the time. He must from the first dismiss from his mind the idea that he must go far for the rare and curious. Accordingly the teacher who is trying to prepare himself for this work should, when he takes his daily walk, give a reasonable and definite part of the time to nature study. He should endeavor to open his mind purposely to as wide a range of objects as he possibly can. Let him not say to himself, there goes a bird, but there goes a robin, there goes an English sparrow, a catbird, a bluebird. Let him ask himself, "What is that note?" Let him not be content that it is the song of a bird, but let him slacken his pace and watch as well as listen. Soon he sees the bird and assures himself that it is the source of the song. Then let him if he can fasten both bird and note in his mind. Or let him pick a flower and look into its face. It is not enough for him to say, "This is ground ivy;" he wants to see in its color the invitation

to the insect visitor, he wants to see in the lines on the corolla the guides which tell the insect how it is to go about getting the nectar. The hairs that perhaps fill the throat of the corolla must speak to him of the unwelcome ant whose visit is an intrusion, or of a drop of water which must be kept from getting at the pollen. It is observations such as these, observations which are connected with the actual life of an animal or plant and not simply with the variations in form and marking which may be used to distinguish the plant when one is seeking its Latin name, that should excite the attention and engage the interest of the observer. Let him get into the habit of picking up almost anything he finds and looking at it until he has made it yield him at least something of information and of interest. It can scarcely happen that he shall find any object, however unpromising it may first appear, that will not, when reasonably examined, especially if he use a hand lens, yield him many a little point of decided interest, a point all the more interesting because it had never been mentioned to him, and came to him with all the pleasure of an original observation.

The Student's Note-book.

32. Of course, such a student will keep a note-book, and if he have any zeal in the matter he will see to it that every day yields him certainly one good, tersely described, nature observation. The student should, from the first, supplement his descriptions with frequent sketch drawings. One day it may be the wing of a fly which he draws. If so, the veins will not only be present but will be correct both in number and direction. The next day it may be the leaf of the red clover, and if so, every leaflet will have the proper size and position. If he be drawing a leaf, the veins will run distinctly in the right direction, and the

margin will conform closely to the actual margin of the leaf. It will not only have teeth on the edge but the teeth will be of the right size and will point in the right direction. They will be related to the veins in such way as to help the observer to see how it happens the teeth are there. Many of the things here written down will be little worth recording, just as many of the problems the pupil solves in learning arithmetic have no permanent value of themselves. None the less, the habit of observing clearly, of describing accurately, and of inferring justly, is growing up in his mind, and it is this habit, and this only, which will make his work command the respect of people who know.

Thoreau as a Guide to Nature.

33. But while the teacher who is at the same time a student is teaching himself clearly to see things out of doors, he should not deny himself the congenial company of those men who have lived near to the heart of nature and have learned her language. These chosen spirits should be his frequent companions, and in conversing with them he will take a delight deeper than any one can know who is not himself a student of nature. After an hour of observation in the field, to come home and sit by the fireside with Thoreau or with Burroughs is to find a congenial companion in whose society the nature lover will find constant inspiration and guidance. Never has America produced a soul more keenly sensitive to every influence in nature than was Thoreau. Nothing escaped his eye; every little change in the landscape spoke to him, every little sign of animal, whether footprint or feather, told him its simple story. He himself had a nature strongly individual, and every description he has given is markedly tinged with his own personality. Accordingly, it is not so much as a record of fact that nature lovers are

fond of the writings of Thoreau. It is for his wonderful personality that we love him most. We long not to be like him, not to see the things that he saw, but to react as sympathetically to our environment as he reacted to his. If our descriptions, without losing truth to nature, could be as thoroughly colored by our own personality as are his descriptions by his own, then we have attained the combination of the culture gained from nature and that gained from literature which is the most beautiful result of nature love.

34. But while Thoreau tells us how we should bear ourselves with reference to nature, it is Burroughs who tells us just what he has seen. The reader who takes up Burroughs for the first time, unless he be a reader of considerable experience, is likely to be disappointed.

Mr. Burrough's Truthfulness.

He seems so simple, so free from all effort, that one scarcely realizes the amount of work and of care he has put into his writing. But if one will read a page from Burroughs and then pick up his own note-book, and read from it, he will not be long in recognizing the beauty and clearness of Burrough's description. Thoreau is a stained-glass window through which we may see nature and see her as a charming picture, but we can never lose sight of Thoreau. With Burroughs we are looking through a window of plate glass and we forget completely the window, which is warding off the raw and blustering air but giving us the winter landscape in all its crisp beauty.

35. There is one other side of the spirit of the work which we must not miss if we are to keep in touch with the times, and yet for which we have no adequate guide in our own country. The great doctrine of evolution, which has transformed the whole aspect of modern study of animals and plants, should form part of the

furniture of any zealous observer. It is the key which unlocks so many mysteries, that no student who is interested in the reasons for things can possibly afford to be ignorant of it. Darwin's great book on the "Origin of Species" is too long and too detailed to interest the average teacher, and he must see evolution face to face at closer range if he is to appreciate its meaning. For this purpose I know no writer who approaches Grant Allen in the interest and clearness of his style. Unfortunately, Grant Allen is an English writer, and he refers to objects by their English names, and consequently we do not always recognize what it is of which he is speaking. But any teacher who will carefully read "Flowers and Their Pedigrees," or Colin Clout's "Calendar," is very likely to find evolution take on a new meaning to him and to see traces of this great process everywhere about us. These books which I have mentioned are the books not of information but of the spirit. From them we do not gather knowledge half so much as we gather inspiration and discipline.

Grant Allen's Suggestiveness.

36. Mention was incidentally made a few paragraphs earlier of a hand lens. There are few things that will add so much to the student's advancement in nature study as the use of a hand magnifier. No matter how simple this lens may be, and no matter how inexpensive, the student cannot fail to derive advantage from its use. But it would be as well for the teacher to own from the first a reasonably good magnifying-glass. To my mind there is nothing better than the one-inch doublet which is made by Bausch and Lomb, and which may be purchased from any dealer in scientific school supplies for a dollar. In using any strange lens the object to be

The Value of a Hand Lens.

examined should be held at the ordinary reading distance from the eye. The lens should be placed nearly in contact with it and then slowly drawn towards the eye until the object becomes clear, the object, meanwhile, being kept stationary. The microscope is an exceedingly valuable instrument when properly used on appropriately prepared objects. Modern scientists would be absolutely lost without it. But it is very easy for one not trained in its use to over-estimate its value in ordinary observation. I feel quite confident that the general observer will find a greater value accruing to him from the use of the hand lens than could possibly come from the use of the more complicated instrument. The student who has only a vague longing for a microscope may well content himself to delay for a long time its purchase, firm in the confidence that while it may yield him much of value, it will be more than likely to lead him away from lines which will be useful to him in elementary school work. So the student who is to be a teacher of young pupils had better put his money into a doublet magnifier and any surplus had better go into books.

Coöperation Between Nature Teachers.

37. In speaking earlier of the sort of books the nature student should read, mention has been made only of such authors as would imbue the student with the aims and purposes of a nature lover. These he may read and re-read; he can never become too fully saturated with them; but they give him only the spirit and he must have access to books which give him the information which he will naturally seek in connection with his out-door work. He needs to know what birds he may expect to find, and then he will be on the lookout for them. He needs to have some means of determining what is the name of

the bird which he has seen. He needs to know the name, and perhaps the relationship, of the flower or the tree which he has met in his walk. A new insect has fallen into his net, a new burr has come back with him from the woods, and these he would like to know. It is, of course, impossible for any one teacher in an elementary school, especially a rural school, to keep about him authoritative books on all these subjects. So it is always wise if he will coöperate with his fellow teachers. If they will come to an agreement that each of them will take one particular field of study for his own, so much the better. Let one of the group decide that he will know the birds, and will help the group to know them. Let another decide that all the trees of the neighborhood must be his friends. Still a third may decide to keep march with the seasons by knowing each flower as it blooms. A fourth may reasonably hope within a single season to become acquainted with the ferns that grow in the locality. Still another member of this possible group will turn his eye to the stars. A glance from his window at night shows him hosts of familiar friends. In summer he sees the Swan float down the Milky Way. In winter, Orion brandishes his club in the face of the threatening Bull. The moon's place in the heavens he notices as she makes her progress along the zodiac, while the planets live true to their name in his eye by changing their position night by night among the stars. It requires a comparatively short time for the earnest student to be something of an authority on one subject in his neighborhood, and when a teacher is known to be well acquainted with trees, or flowers, with insects, or birds, people in the neighborhood turn naturally to him whenever what seems a strange specimen falls into their hands.

38. Whether or not he make a personal collection, the teacher should certainly gather, and have his pupils gather, large amounts of material for the school. The closet, the attic, or the basement must have a place in which to store this material in orderly fashion. If possible, boxes of uniform size, that will stand well in orderly rows, should hold this duplicate material which is to go into the hands of the pupils. Every box should have marked on its end clearly the name of the objects which it contains. I find empty chalk-boxes to be exceedingly convenient for such purposes as these. One of them may contain pieces sawed from the limb of a tree and smoothed with a plane to show the rings of annual growth; another may have the seed capsules of the velvet leaf or of any other of our plants; while still another may hold pebbles worn by the action of the water. These boxes should be piled after some scheme of classification so that it is easy to find the particular box wanted at a moment's notice.

The Storing of Specimens.

V

SUBJECTS SUITABLE FOR NATURE STUDY

39. A GOOD teacher, who is fond of nature, once said to a companion who was trying to do nature work, and who complained of a lack of material, "Sweep your room and look at the dust." His meaning was plain. There is practically no material which will not yield interesting lessons if handled in the right way by a person full of enthusiasm and thoroughly acquainted with his subject. But there are few teachers who can fill themselves with enthusiasm concerning dust, and fewer still who would recognize under a magnifying glass the miscellaneous assortment of objects which will turn up in what we commonly call dust. For the ordinary teacher there must be something of definite interest in the subject itself, or the lesson will be entirely perfunctory and the class without interest. Accordingly, the wise teacher will be careful to select, at least in the early portion of the work, objects in which the pupils will be interested so soon as they are brought face to face with them. It would be going too far to suggest that a teacher should never present a subject which does not produce immediate excitement among the pupils, and should lay aside the subject so soon as the excitement had abated. None the less, one of the first essentials of good teaching lies in securing the interest of the pupil, and the teacher's time should be very largely spent not so much in interesting the pupils as in cultivating in the pupils a many-sided interest; that is, in broadening and

Use Attractive Material at First.

deepening the interest of the pupils, and in teaching them to linger longer and to delve deeper into each particular subject on which they dwell.

Less Attractive Material Comes Later.

40. The first lesson in nature study, while it is a novelty in the hands of the teacher as well as in the minds of the pupils, must be based on some subject which of itself attracts interest. It is this early lesson which will do much to decide how soon nature study shall be an interesting and effective part of the school work. We must take care, too, that the first lessons are not given on subjects for which there is repugnance on the part of the pupils. The teacher must not start the lesson by bringing a snake into the school. There is no question, whatever, that at the proper time and place the snake will be exceedingly interesting. It is the victim of so distinct a prejudice that it is a merit on the part of the teacher simply to remove this prejudice; and if one's horror of a snake has gone and one has learned the two dangerous snakes to avoid, it is easy for one to realize the real beauty of the snake and to understand that, even from the standpoint of the farmer, the snake has a right to live. Of course in his own right he has the same claim to live out his days undisturbed by man as has every animal that does not distinctly militate against the success of the human race. Not quite so bad is the introduction of the toad. This little creature, which late in the course will form one of the very best materials for study, is altogether out of place in the early lessons, when his presence is enough to bring a shudder to many a child who is the victim of ignorance on the part of his elders, and who has come to regard the toad as an horrible object whose handling is attended with the formation of warts.

41. It will be found that, especially for the early work, plants are likely to answer better than animals. There is practically no repugnance on the part of most people to any plants which are likely to be used for this purpose. The flowers of the spring and summer, the fruits of fall and winter, are so charming and attractive that they can be easily and readily used. Then, too, less harm comes from their abuse. While it is perfectly true that pupils must learn not to ruthlessly weed out our flowers, it is none the less true that to do so brings less harm to the child than the wanton destruction of animal life no matter how low in the scale. Yet be it said that the objection to cruelty to animals on the part of children is valid not so much on account of the harm done to the animal as to the effect upon the children themselves.

Plants Rarely Repel.

42. Suppose it is decided that an animal shall be the subject for study and this animal shall be taken into the school-room. There will always be in the class a portion of sensitive children to whom the very thought of an animal in captivity is a pain, and this can be made a means for moving an entire class into a care for dumb creatures. The animal should have abundant room in the enclosure and conditions approaching those which he had out of doors. The study of these conditions, the arrangement of the enclosure to meet such conditions, is one of the most profitable forms of nature work that can be given to children. A mere enclosure is all the teacher need furnish. The surroundings of the animal in the enclosure and the food he should eat should largely be questions for the decision of the pupils. There used to be a very considerable infusion of mineralogy into the early work of the schools, but it is doubtful whether much of it is

Take Good Care of Live Creatures.

useful. I do not believe pupils below the eighth grade have any occasion to know or care for quartz, feldspar, mica, and hornblend, or to know granite and gneiss, and syenite, as the result of their combination. But any grade of pupils may be interested in a lesson on coal, particularly the sort which is commonly used in their neighborhood whether it be soft or hard; in slate, if the roofs in their neighborhood are made of slate; in pebbles, that show the action of water; in limestone, if limestone is common to the neighborhood, and in the main kinds of building stone which are used in the construction of the buildings about them. But this acquaintance with these materials need not go into the question of their mineral constituents.

43. There is another side of nature of which children might well be taught to know more. It will be found interesting from the first and will be a delight in later life, if when they lift their eyes to the starry heavens on a clear night, certain of the great groups of stars whose configuration changes so slowly that hundreds of years make no difference to the naked eye, should be familiar acquaintances. Every child should know the Dipper, and know also the other group which shows best when the Dipper shows least, the Lady of the Chair. And the crisp winter sky ought always to show his familiar friends, at least, the magnificient Orion and the Seven Sisters, together with the splendid Sirius in the head of the Dog. Such objects as have been mentioned here will be suggestive to the teacher and long before they have been exhausted he will find for himself what he may readily choose from the objects round about him; will find what things will yield him success and his pupils the best results.

Acquaintance with the Heavens.

44. A friend of mine once wandered into the class of the general editor of this series. The teacher was giving to a group who were studying pedagogy under him, directions for the first steps in the teaching of some subject or other, I no longer remember what. After he had described all the details of the work they were to do, and had finished his instructions on the subject, he looked up with that look on his face that so many of us have learned to love, and said, "But whatever you do, see to it that you make the child's first vision glorious." In no other subject is this more possible or more desirable than in nature study. Remember that it is not so much information which we are after as an attitude, not so much knowledge as spirit. Everything that is done must link itself with human life and must be filled with human interest. Some people worry at times because the nature teacher makes a flower speak, and say it is folly to teach such things; but if only in personifying a flower we see to it that what the flower is made to say is what the flower really says inarticulately, then we need not fear lest we should give to children a wrong impression. Most of the criticism which has been aimed at nature study has come from the scientist who fears that the work is fragmentary and puerile. The truth of the matter is that the child's mind is fragmentary and that there can be no such thing with children of the age of those who commonly take nature study as work which a scientist would by any possibility consider thorough. We must remember Bailey's maxim and think in nature study more constantly of the child than we do of the subject which we are teaching. No matter how desirable information may be, it is absolutely useless to try to give it to children who are not ready for it.

"Make the First Vision Glorious."

VI

THE WORK IN THE SCHOOL-ROOM

45. THERE are comparatively few schools in which there is any definite place upon the program for work in nature study. With few exceptions such work is scheduled, if scheduled at all, for a Friday afternoon. Accordingly, in such a program it never comes to be anything except a pleasant entertainment. This is perhaps better than that it should find no place at all in the school work; but, I am quite convinced, when we reach our ideal program there will be no period for nature study found upon the schedule. Already the country is crying out against the crowded condition of the curriculum. Any attempt at alteration must consist in cutting out rather than adding, in simplifying rather than in further distention. And so it is that nature study, if it is to find a place at all, must succeed in doing so without displacing anything, and without adding any to the time spent in the work. To the inexperienced teacher this would seem to be an impossibility, and yet I am sure that while I do not underestimate the value of nature study, if I were empowered to make the course of study for a school system and had under me a corps of enthusiastic teachers who would be willing under my guidance to do whatever I should direct, I would have in the course no place assigned to nature study. In other words, nature study when it once comes into the schools will not be a new thing, but simply a new form of doing an old thing. It will not be a new branch;

No Scheduled Time for Nature Study.

it will simply be a new phase of many of the old branches.

46. In the first place, nature study will cast its influence over the drawing lesson. Every progressive school to-day does a certain amount of drawing. All good drawing is from the object; nothing else is worth while. What more natural than that the teacher should choose, as models for his drawing lessons, the objects which he intends to use as the subjects for the nature-study lessons that week? The first requisite of good nature-study work is close and careful observation. The first necessity of good work in drawing is close and careful observation. What more natural than that the teacher should combine these two? He need not write upon the program that the 2:25 period is a period for drawing and nature study; it is simply his drawing period, but upon that particular day it is also his period for nature study. It takes no more time than if he were giving the pupils a book or a chair or a peach-basket to draw, only the teacher has decided that the subject for this week's work in nature study is to be, let us say, an apple. When the time for drawing comes, perhaps on Monday afternoon, the object which the children draw is an apple. If to the outline of the fruit the pupil will first add whatever markings may be on the apple, and then perhaps follow it with color, even though this color can be applied only with crayons, the first step towards good nature-study work will have been taken. That is to say, every pupil will have had occasion and opportunity to look carefully at the exterior of an apple, and nothing else evidences so clearly the fact that the pupil has carefully examined the apple as his power to correctly reproduce it by drawing. Thus Monday's nature-

Nature Study and Drawing.

study lesson has taken no time out of the regular program, has added nothing to the work for the teacher, has displaced nothing, and yet has been well done. When Tuesday comes, the drawing lesson may go to some subject connected with other work. To-day the drawing lesson is not a nature-study lesson.

Nature Study and Language.

The language lesson comes now to take up this burden. Supposing upon that day the object is to show the use of the adjective. Each question is so directed by the teacher as to require the use of an adjective in describing some feature of the apple, and thus once more the work of the school goes on; work is done which everybody knows to be necessary and desirable; work in the use of the English language, which nothing should be allowed to displace. And, once more, we have had our nature-study lesson. Perhaps it is the compound sentence which is to be worked over at this particular time. Every question that the teacher asks should be so constructed as to draw forth from the pupil not only a compound sentence, but information which the pupil has gained, or can think out, concerning the apple. The sentence will be better, more vital, more individual, when the pupil makes it in response to a question for definite information, than when it is simply a made-up sentence, the subject matter of which has no necessary relation to anything whatever, but only happens to pop into the pupil's mind. So Tuesday has seen another successful lesson on the apple without the loss of a minute of time from any subject and without the loss of a single aim that would have been secured if the nature-study lesson had not been brought forward. On Wednesday, perhaps, a class in drawing once more attacks the problem of the apple. Each pupil should have in front of him the

half of an apple cut from stem to star, and the half of another apple cut crosswise. To the drawing teacher this new lesson is simply progress from the drawing of a sphere to the drawing of a hemisphere, but to the nature-study teacher it is far more. The structure of the apple shines out from the cut surface, and the child who must draw what he sees on this cut surface cannot come away from this lesson without a new idea of the apple.

47. I would like to speak of the two sorts of drawing. The teacher of art usually recommends the use of the blunt pencil and broad lines, for to the teacher of art it is the distribution of light and shade which is the most interesting part of the problem. With this sort or drawing I have no quarrel whatever. Those who know far more about art than I do are agreed that it is the best form of line for children's work, and I would not for a minute wish to run counter to the well accepted rules of drawing for elementary pupils. But I think it will be quite possible to distinguish between making "pictures" and making "record drawings." A picture is primarily intended for beauty of effect, and record drawing is intended to be the graphic statement of structure. For this purpose the pupil should use a sharply pointed pencil and should only draw actual structural lines. Light and shade may be omitted from these drawings, and only such lines be produced as correspond to definite lines in the structure of the object. I think this plan will not conflict with the work in drawing, providing we make it clear that this is the day for "record" drawing, and the children will without difficulty, I believe, use this form of drawing when they are making record work.

Record Drawings.

48. Thursday has come, and to-day, perhaps, the

geography class may be combined with the nature-study lesson. If the lesson happens to be a general one on the United States, then the question may be started as to where the apple grows. Perhaps a little questioning from the grocer may help in the solution of the problem. Once having started in placing the apple in its proper locality, the transition is easy to studying the distribution of the great fruit areas of the country. It will not be long before the pupils have realized that the apple, the peach, the orange and the banana will illustrate, as well as any other natural product, the dependence of our vegetation upon climate. In this connection the transportation of these productions will be of great interest. Again no time has been lost; again every assigned duty has been provided for; and again nature study has found its place.

Nature Study and Geography.

49. With Friday afternoon comes the sense over the school-room of the close of the week. Perhaps even over the teacher comes a natural tendency to slacken up the afternoon work. Nothing will counteract this more thoroughly than to throw into this session work that shall be somewhat out of the ordinary and possess more than common interest. Now is the teacher's opportunity to bring in his contribution to the richness of the nature-study lesson. He himself may tell a new and interesting fact. He may have directed some older pupil to prepare a paper. He may have secured the coöperation of some good fruit-grower of the neighborhood, who will tell what will interest the pupils. It will undoubtedly have happened in the course of this study that more than one apple has been cut in two out of which has tumbled a "worm." It excited the interest of

The Summing Up of the Week.

the children and questions were asked concerning it, but the teacher staved these off at the time. Now is the opportunity to tell of the codling moth that came while the apple blossoms were on the tree and laid her eggs inside their dainty corollas. From one of these eggs soon emerged a caterpillar which promptly ate its way into the core of the apple and the opening by which it entered soon grew over. Once upon the inside, this larva, safe from all intrusion, may eat its way about until it has grown to full size. Now the apple falls from the tree, the worm creeps out of the apple and under loose bark and there lies over winter, transforming in the springtime into the full-grown moth. This emerges, ready to push its egg into the freshly-budding apple blossoms. This lesson will not be complete until it has shown the children how foolish it is to allow windfalls, as these early dropping apples are called, to lie until the larvæ can emerge and enter the ground. The farmer who will permit this to go on is simply breeding more trouble, while he who will gather up these apples and either feed them to the hogs or convert them into cider, will get value out of the fallen apples and do much to alleviate the damage to future crops.

Naming Apples.

50. If the teacher have in the school a bright pupil who can be entrusted with this commission, a farmer's bulletin may be secured without cost from the Department of Agriculture at Washington, which will name the main varieties of apples. This pupil may endeavor to gather from among the apples brought in by his fellows, typical examples of as many varieties as he can. It may be that there is in the neighborhood some man who is a careful fruit-grower. Perhaps he can be persuaded to come that afternoon and show the children what is meant by grafting,

5

bringing a few twigs with him and actually performing a grafting operation before their eyes, telling them why we graft trees and when it should be done. Some such exercise as one of these mentioned will serve to close pleasantly the school session, and I feel sure that the week whose work is thus permeated with a thread of definite purpose that links its several parts into a coordinated and coherent whole, will prove to have been an inspiration to the teacher himself and to stay with more than ordinary persistence in the mind of the pupil.

Subjects for Composition.

51. Nothing makes for clearness of language like definiteness of idea and of purpose. These qualities can be fostered by assigning to the pupil some clear-cut topic on which to write. Let the subject be not the apple, but the color in the apple, and the teacher may ask why is the apple colored? What part of it takes the brightest color? Why is this the case? Is there any use in its being so? The pupil who has these questions asked to him and is sent not to an apple but to a tree bearing apples, will, if he has had any reasonable preparation, bring back interesting and profitable lessons, as well as a coherent composition. A more difficult problem, and yet one not beyond the power of solution by the boy who is interested in such questions, is to see what is the difference between the whiskers of a cat and the whiskers of a dog. Of what use are these whiskers? Is the horse more like the dog or like the cat in this respect? How about the rat? A live boy will find here much exercise for his mind. In his composition he should distinguish very carefully, and show plainly that he does distinguish, between those things which he has seen and which he can clearly state, and those things which he simply infers and which may be entirely wrong. It is

in this work that training in truthfulness is readily secured and character building can be most carefully attended to.

52. A further suggestion as to the question of geography may not be out of place. Let us suppose that the lesson is to touch upon the Gulf states. If it is possible to look out over a field of oats, and study the hollow stems of the plants, the grains at the top, the crowded condition under which the cereals grow, it is no difficult matter, when once the general idea of a grass has been gained, to go in an imaginary way, to the South, to cover the oatsfield with water, and convert the waving oats into standing rice. Nor need it be difficult, if the milkweed pod is growing by the road-side, for the children who have seen this pod split open and each seed sail away in the wind by its tuft of fluffy hair, to see the fields of the South covered with the pods which, bursting, pour out the wealth of seed buried in white, curly hair, which we have come to know as the cotton. Any pupil who has pulled a stalk of sweet corn and chewed the tender end which he broke just above a joint would not have much difficulty in realizing how the cane has packed away its large store of sugar.

Subjects that Grow.

53. If the subject happens to be the Sierras or Alaska, or Greenland, or the Alps, and there be upon a neighboring roof its load of winter snow which has slowly moved until its curled edge curves down over the projecting eaves, then we have at hand a good lesson indeed. For just exactly the movement which has brought this snow down the roof, and has made it bend and curl over the edge of the eaves, is the precise movement which has pushed down the gulleys of our great mountains their creeping tongues of snow,

Glaciers at Home.

converted at the bottom into ice which men have called a glacier.

54. Let all the drawing and all the written language work which is done in nature study be done upon paper of uniform size, perforated at the edges. Let a little Manila-paper cover be made for each pupil's work, and at the close of the school term let all the pupil's work in nature study be collected, arranged and tied up in one sheaf. Then it will be seen how large an amount of really profitable study has been done, and this without one minute's loss of time or effort from any other branch. From each pupil should be selected the best of his work, and these selections should be fastened together into a school note-book. If this method is adhered to for several years, all the best work which has been done through these years on one subject can be bound together in one book and the result cannot fail to be interesting and stimulating to the pupils of the new year.

Bind up the Notes.

55. There are a number of advantages to be derived from having the work in nature study occupy no part of the school program, but to be secured, instead, by serving as one subject one day and another subject the next. In the first place, as suggested before, there is no time lost and no subject in the crowded course is displaced. In the second place, there is far less probability of criticism from those who are not closely in touch with the school work, and who would be likely to distinctly object to practically any new thing introduced into the course. These are only minor advantages, to my mind. The greatest advantage to come from it is the fact that the teacher and pupil will gradually both come to see that our artificial method of separating between branches is simply a con-

No Time is Lost.

venient artifice for school purposes. To the merchant, his geography, his spelling, his reading, his arithmetic, his book-keeping, his history, are all inextricably mixed together in actual life, and it would puzzle him were he to confine each of them to a definite period of the day, If this method is pursued the minds of the children will not be likely to grow up into what one of our educators has humorously called "water-tight compartments" each of which contains a separate subject and between no two of which is there any means for communication.

VII

THE EQUIPMENT OF THE SCHOOL-ROOM

56. WHILE it is quite possible that the ideal work in nature study should be done out of doors entirely, in actual practice this is neither possible or even always desirable. It often happens that profitable observing-ground is far away from the school and that the pupil would lose too much time in going to and fro. Such work in nature study would soon be vetoed by both directors and patrons and very properly so. If the nature study is to have any vital hold on the school it must know its place and it must not disorganize the general work. Accordingly, it is often preferable that nature should come to the children, and there are many circumstances under which it is really better that this should be the case. The nature class can easily degenerate into a mere picnic, and picnics will be slow in finding their place in the curriculum. So it happens that the teacher must in most cases provide the material which the children are to study. This means a very considerable amount of work and the teacher must learn early to minimize this trouble as far as possible. If his work is planned for some time ahead, it is often not difficult for him to gather materials either on his way to or from the school or in short détours from this route. Once a week the teacher should have a good country walk, and this should bring much material. When the children have become eager in the matter of nature, if encouraged to do so they are sure to turn in a great deal of material. The wise teacher

Material Must be Gathered.

will show his wisdom in the manner in which he receives these offerings. One should take everything that comes, and thank the child that brings it. If possible one should always tell the child some interesting fact concerning the specimen which he has brought. The pupil should be encouraged to write a label that can be fastened to the object, and then this object can be laid aside. If it is really worthless, the child's feelings should not be hurt by having it discarded in front of his eyes. If the contribution is courteously received, it is quite certain that there will gather about the school a very interesting body of material which will be valuable in the nature study work.

Systematic Storage.

57. I have found it very desirable in my own case to use a large number of boxes of uniform size, which shall contain much of my material for nature work. Empty chalk-boxes serve the purpose well. Each box should be marked on its end with the name of the material which it contains, and then the boxes grouped on shelves, similar materials being kept close together. Some of my boxes contain blocks sawed from vigorous shoots of Ailanthus. In contrast with these, I have in another box blocks sawed from a shaded branch of the Linden, in which nine or ten rings will be found in a twig not more than three-quarters of an inch in diameter. Still other boxes hold sections of wood cut lengthwise or pieces of corn-stalk, some cut lengthwise and some crosswise. Others of these boxes contain fruits. One will hold chestnuts in the burr, another will have the seed-pods of the milkweed, still another the capsules of the velvet leaf and near by we find the prickly capsules of the "jimpson" weed. The number of attractive seed-pods that can be gathered in the fall is simply astonishing. Then, too, I collect the fruits

commonly called burdocks and Spanish needles. The first time a child examines a Spanish needle with a magnifying glass, and finds how it is that they stick so tightly to one's clothing he will gain an impression which he will be slow to lose. Nor need the boxes contain only plant materials. Animal specimens are often quite as available and quite as easily kept. The shells of our ordinary mussel and snail are very interesting, and though we do not go to the ocean, oysters and clams come to us, and their shells are excellent objects to study. I might remark that oyster shells are so absolutely paired that no two which have not grown together can possibly be made to fit each other. It is my habit to see that I get both shells in the pair of an oyster, and when they are not in use I keep the pair tied up with a piece of cord. It is easy also to gather the nests of the mud-wasp, or the paper nests of the wasp that fastens itself under the eaves. It is always wise, where possible, to gather enough material of one kind to go around a class and then to have enough left over to make up for the wear and tear of several years. This will very materially lighten the teacher's work. But these materials are not the best. If possible, living material is what is most desirable, and where it can be had, should certainly be used.

The Aquarium.

58. Of all the means for keeping live animals in the school-room, the best both in simplicity and interest is the aquarium. I hear people complaining of the great

Keeping an Aquarium.

trouble in keeping an aquarium, but that is simply because they do not know how to go about it. The usual complaint is that the aquarium will not keep sweet, though the water is changed every

few days. Indeed at first, while the newness of the occupation has some charm, the water is often changed every day. As a matter of fact, when everything is working as it should, there is no reason for changing the water. In our own school an aquarium had no change of water for eighteen months, and then only was emptied

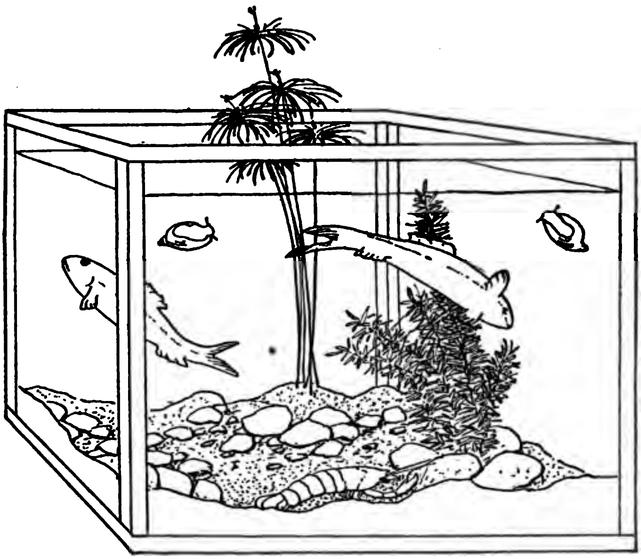

FIG. 1—A HOME-MADE AQUARIUM

because the teacher who owned it moved away and wished to take it with her. The first qualification of an aquarium, and the only indispensable one, is that it should hold water. A china bowl is better than nothing, and any ordinary fruit-jar makes a fair substitute for a good aquarium. But if one is expecting to study the creatures in the aquarium, and not use it simply as an ornament, it should have rectangular sides. Any other form so distorts the apparent shape of the animals

inside the vessel as to make the study of them difficult. Every one must have noticed that in the ordinary fish-globe, a very small goldfish will look, when viewed through the side of the jar, enormously big, and often both head and tail will fade off into a golden haze. There is no shape of aquarium less adapted to purposes of study than this most familiar of all forms, the globe. Accordingly it is far better where this is possible to have a vessel with rectangular sides. The ordinary square candy jar makes a very satisfactory vessel. Of course it is quite possible to buy from dealers in such supplies a highly satisfactory rectangular aquarium, but the cost is greater than many school committees care to put into such a piece of apparatus. Quite a number of methods have been advanced by which teachers can make their own rectangular aquaria. The method which has proved most satisfactory in my hands is one which any teacher, with a little patience can follow. The materials to be used consist of five sheets of glass, a roll of surgeon's adhesive tape about one inch wide, and a small can of bath-tub enamel. One roll of tape and one can of enamel will suffice for several aquaria. If it is desired to use glass 8 x 10 inches in size, the dealer should cut two of the pieces down to the size of 8 x 8. These will serve as the ends of the tank, the remaining pieces serving as the sides and the bottom. This box is held together by means of the adhesive, which is put as a strap along each edge of the box. There should be a strap along the inner edges as well as the outer, so that a double reinforcement of tape passes along every edge of the tank. Around the top of the aquarium a strap of the adhesive is run, half of which is on the outside and half on the inside. The success of this process depends absolutely on the

Making an Aquarium.

patience with which this adhesive tape is rubbed firmly into place. Time spent on this process saves much subsequent difficulty. After the adhesive has been in place for twenty-four hours, two or three coats of bath-tub enamel are painted on the tape and over its edge, so as to leave a line of enamel on the glass. This prevents the water from soaking under the edge of the strip of adhesive. Each coat of enamel should be allowed to dry thoroughly before the next coat is put on. When this process is completed and time has been allowed for drying, one will have a tank which is sound, strong and neat.

The Balanced Aquarium.

59. I have said previously that it is not necessary to change the water of an aquarium. It is well known that green plants absorb carbon dioxide and that they give off an equal amount of oxygen. On the other hand oxygen is rapidly absorbed by animals, while they are continually throwing off carbon dioxide in equal quantities. It is at once apparent that if we have the proper proportion of animals and of plants the plants will throw off the oxygen which the animals need, while the animals in return will pass off an amount of carbon dioxide exactly equivalent to the oxygen they have absorbed. It is only necessary to see that we have both animals and plants which are accustomed to living beneath the surface of the water and that they are present in the proper proportion.

60. When one intends to stock an aquarium, he should take his jars and his net and go to a country stream. He should gather a number of stones sufficient to cover the bottom of the aquarium, and these should be washed thoroughly to free them from any decomposing animal or vegetable matter. His next

task is to gather a considerable number of plants which grow with their leaves beneath the surface of the water.

Water Plants. Any plant whose roots alone are in the water may ornament the aquarium but is of no practical use for the purpose of keeping it sweet. There are many plants which grow with their leaves beneath the water. When gathered from the stream, they should be washed free from a greenish or brownish deposit, partly dirt, partly vegetable matter.

61. Now the animals that are to be kept in the aquarium should be gathered. Looking carefully among the stones, in clear running water, we see the open edges of the mussel or fresh-water clam. This creat-

Mussels and Pond Snails. ure is buried almost completely in the stones and sand of the bottom of the stream, only a thin edge protruding, and this is kept open to allow the water to enter and leave the shell. Our next care is to feel among the leaves in the stream for pond snails. They will be found creeping on the stones or climbing the stems of the water plants. Four or five of them should be present in any aquarium. The animals thus far mentioned are desirable for the sake of the health of the collection, independently of any interest we may take in their own activity. Now we may introduce a few of the animals we care to study.

62. Fish will naturally be among the first objects to attract our attention. To my mind the little fish of our country streams are much more interesting than the goldfish of the shops. The sunfish is the most pugnacious and independent of all the fish I have kept. By

Desirable Fish. way of contrast a small catfish is interesting. A minnow, if of sufficient size not to fall a prey to any of the others, will nicely complete our collection. On returning home the aquarium may be

stocked. The stones, thoroughly washed, should be placed in the bottom of the tank. Water, preferably from the stream from which the animals were taken, but certainly not filtered water, should next be added. The plants which are to go into the aquarium should now be chosen and a good supply should be used. Plants are so much more sluggish in their life activities than animals are, that a considerable number of them is necessary to counterbalance comparatively few animals. The base of the stems of these plants should be tied fast to the stones used in the bottom of the aquarium. The mussel should now be placed on the stones, four or five pond snails put into the jar, and lastly the fish. The mussel will soon bury himself among the stones and begin drawing the water into one of his funnels and letting it come out of the other. However cloudy the water may be when it enters his body, it leaves it clear. The result is that in a few days the water of the aquarium will be absolutely transparent.

Keeping the Glass Clean.

63. One of the difficulties in the maintenance of an aquarium is the fact that a green scum is very apt to form upon the glass. This coating consists of a low form of plant life. The pond snails in their traveling up and down the glass will devour the green scum. If pond snails are put into the aquarium when it is first started, this scum has no chance to gain a headway. Even when it has appeared, if it is not too heavy, the addition of the snails will serve to effect its removal. The tank should not stand where it will receive direct sunlight for more than an hour or two in the day. It does not need direct sunlight at all, though it should not be placed where there is not a fair quantity of light.

64. For the first week the collection needs frequent

watching. So long as the fish swim freely near the bottom of the water, it may be counted certain that there is a sufficient supply of oxygen and hence that there are plants enough. But when the fish persistently swim near the surface, we have a sure indication that the plants are not handing over to the water as much oxygen as the fish need. Our remedy is plain. Either we must add more plants or we must take out some of the fish. There should be, here and there, spots entirely free from plants. Otherwise it will be too difficult to see the animals clearly enough to make it possible to study them.

The Balanced Aquarium.

65. To those who visit the sea-shore, a salt-water aquarium will prove very interesting. This is quite as easy to make and as easy to maintain as a fresh-water aquarium. Of course in this case seaweeds form the plant life and marine animals the animal life of the aquarium. It is best, however, to confine ourselves to the greenest of seaweeds and to a few small animals. Small seashells with their natural occupants will prove most interesting as will barnacles and sea anemones.

The Salt-water Aquarium.

66. It is often well to lay a light covering over an aquarium. This should especially be done while the room is being swept. Water will always slowly evaporate and when it does so there is apt to be left a line above the surface of the water. This may be obviated if upon first filling the aquarium we make a mark of some sort on the outside of the glass and then take care to add a little water now and then to keep the surface always at precisely the same level. In pouring new water into the aquarium, it is well to insert one's hand into the aquarium, just below the surface of the water, and then to pour the added water

Adding Water.

upon the hand. This prevents the formation of currents, which would make the water cloudy. When sea water evaporates from the salt-water aquarium it of course leaves the salt behind, and hence to remedy the evaporation from such an aquarium we must continually add fresh water. It is needless to remark that the rivers are constantly doing this to the ocean.

67. One of the frequent sources of trouble in an aquarium is the matter of feeding. Fish should be given very little food; I have known fish to be left when a family went away for the summer and when they returned the water in the aquarium had evaporated to less than half its original quantity. The goldfish had had no food excepting what little they may have eaten of the plant life in the aquarium, but they certainly seemed none the worse for their experience. The fish food sold in the stores is simply rice flour and water and has no material advantage over a piece of cracker except that it does not so readily break up and foul the water. Little food should be thrown in at a time and after the fish have fed for half an hour the rest of the food, if any be unconsumed, should be removed.

Feeding the Animals.

The Live Cage.

68. It will very frequently happen that the teacher would like to keep a small animal in the school-room. This may be made an apparent cruelty or the animal may be made to seem so much at home that there seems to the pupil to be no sign of cruelty about it. Of course anything that will hold the animal, will serve the purpose, but I have found a form of live cage which meets my needs exceedingly well. There is a wire netting commonly sold at the hard-

Making the Live Cage.

ware stores which runs about four meshes to the inch, and these meshes are soldered where the wires cross each other. If the cage is to be a completely closed one, I take a length of this netting, sufficient to form bottom, two sides and top and I bend it into that shape. With wire, I sew the two ends together, thus forming four sides of my box, two pieces of wire netting are cut off, of such size and shape as will form the other two sides of the box, and these are also sewn fast with wire. The box is now completely closed. With the shears I now cut a door-way in one side. The piece thus dropping out can be made to serve for the door, but a slightly larger piece is preferable. This too can be attached at one side by means of a piece of wire. Such a cage has the unusual advantage that it can be kept positively clean, even with the animal inside of it. When necessary it can be put under a hydrant and thoroughly washed. It should ordinarily be kept standing on heavy paper, and if this is frequently removed the whole contrivance keeps entirely sweet. In practise I find it often convenient to make such a cage of very considerable size, and then divide it by sewing into it partitions of wire netting just as the cage itself was sewn together. Animals which are natural enemies show sometimes considerable fear when first placed in adjoining cages; but it is astonishing how soon all signs of fear die away. This happens even when the animals are placed in the same cage, providing they do not immediately attack each other. I have had mice to sleep in the folds of a blacksnake with apparent entire comfort to both of them. Subsequently a suspicious bulge in the blacksnake made it evident that one of the mice was reposing on the inside. The remaining mouse, however, seemed to have no idea that the fate which befell his friend

was likely to be his own, for he continued to repose daily with entire complacency within the folds of the snake.

69. It is both ethically just and at the same time pedagogically wise that each animal which is kept caged in the school-room should have the conditions of his cage as nearly as may be those which he would find outside, excepting in the matter of his freedom. It will hence be an excellent exercise for any pupils to be given the task of arranging the box or cage so as to make the animal as much at home in it as it is possible. Animals should always be fed as nearly as possible the food which they naturally eat, but a fair approximation is all that is necessary. Cold-blooded animals are far more likely to be overfed than to be given too little to eat.

The Cage a Home.

Collecting Insects.

70. There are comparatively few kinds of animals which can after death be inexpensively prepared so as to serve as specimens in nature study. Few teachers will develop sufficient skill to mount either the mammals or the birds, and when one succeeds in mounting one of these creatures it answers but indifferently the purpose of our work. They are so active when living that it is almost impossible to mount them well enough not to be seriously disappointing. It is far better to study a few live mammals than many dead ones. Insects are very interesting when kept alive, and this should be often done. In addition they form the best materials for the young collector to work upon. There seems to be so little cruelty in the collecting of them that even a child realizes the difference between trampling on a beetle and stoning a cat. Science

Preparing Insects.

says that the lower animals suffer far less pain than those higher in the scale. Insects have one enormous advantage for the purpose of the collector. They have their skeletons on the outside and the flesh dries up within them. A dead and dried grasshopper has the same external appearance that the live one had and this is quite as true of beetles, butterflies, and bees. Accordingly the only steps necessary in preparing an insect are, that his body should be placed in an attractive position until it has stiffened, and then it must be kept where moths cannot deposit their eggs upon it. It is this latter which presents the real difficulty with insect mounts. There is no trouble about making them, but most amateur collectors in adjusting the boxes allow moths to get into their specimens and utterly ruin them.

Insects Usually Safe to Handle.

71. The catching of insects is usually a very simple matter. Contrary to the generally received idea, a very large proportion of them may be simply picked up. There are few insects which have the power to do us harm and the general fear of these creatures is ordinarily quite without basis. The beetles as a whole can do no harm, though they have often the name of pinching-bugs. Now and then a few larger beetles of our neighborhood really have jaws sufficiently strong to make a puncture, but in few cases do we suffer enough for it to be worth calling a hurt. In none is there any harm from the bite, which very rarely punctures the skin. Flies almost without exception may be caught in the hand, without the slightest hesitation. Dragon-flies, big as they are, are equally without power to harm. The so called seventeen-year "locust" and his larger green cousin are equally free from power to harm. The truth of the matter is, that when we get out of the group of the bees

and the wasps, there is not one insect on an average in ten thousand which may not be handled with entire impunity. Accordingly insects may be frequently captured with the bare fingers. There are certain kinds, as for instance the butterfly, in which the delicacy of the coat is such that capturing by the fingers would result in the practical destruction of the beauty of the specimen. Where this is the case, some other method must be employed. A bottle with a wide mouth and a stopper to fit serves as a means of capturing the many insects which one would not handle. A tin box and its readily removed lid serve equally for the same purpose.

72. But any one who wishes seriously to study the insects, should certainly provide himself with a net. A piece of wire, of brass or iron, about forty inches long should be curled into a hoop by lapping the ends for eight inches. These ends should then be given a twist or two, and turned at right angles to the hoop. The ends of the wire extend about four inches from the hoop. A light but firm stick, not over three-quarters of an inch in diameter and about four feet long, should have its end inserted between these two projecting wires and these should be bound together by means of small wire or twine. A bag of tarlatan, or of mosquito netting, should now be made. This bag should be just large enough in the mouth to fasten closely about the hoop of wire and should be well sewed on. The bottom of the bag should be a straight line, no attempt being made to pucker it or shape it into a point. I have found a very satisfactory net which can be constructed with a little more care and expense. Every dealer in sportsmen's goods sells an instrument, intended to serve as a gun cleaner, which separates readily into three parts, which screw together to make

The Insect Net.

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or other cleaning materi
made of wire whose ends
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74. Among constant co

bottle or can is a very common instrument. A piece of cyanide of potash about the size of a small chestnut is dropped into the bottom of a can or bottle with a wide mouth. Plaster of Paris in the dry powder can be poured in until it just covers the cyanide. A little more plaster of Paris mixed with water to form a thick cream is poured upon it, and the instrument is complete. Through this plaster of Paris floor, the deadly fumes of the cyanide arise with sufficient power to kill insects. This power lasts for a considerable time, even for months. The one serious objection, however, to the process is the fact that the cyanide is so deadly that it practically should not be found outside of a laboratory or a drug-store, excepting in the hands of people thoroughly alive to the danger. I have abolished it in my practice. I take a wide-mouth jar, holding about eight ounces and having a screw-cap top. Fine stick candy is often sold in such jars. Into the bottom of this vessel I put about an inch of absorbent cotton and I press down upon this a cardboard disc large enough to fit tightly into the jar and hold down the cotton. Through this cardboard disc a number of holes are cut, to make it easy for gasoline, when poured into the jar, to run through the card and saturate the cotton. This answers quite as well as cyanide, though its effects quickly pass away. A small quantity of gasoline must be poured into the jar at intervals during use.

The Cyanide Bottle.

75. After the insects have been captured and killed, the next step consists in arranging them so that they may be stiffened in a natural and attractive position. A good plan is to use the box known to the trade as the Riker mount. Its great disadvantage lies in the fact that while the box could be easily made by any-

body, it is protected by a patent, and the boxes must accordingly be purchased. In the Riker mount, a shallow box is filled with cotton. The insects after being stiffened are laid upon this cotton and the lid, which consists of a sheet of glass with a paste-board rim, is slipped over the box and pins are stuck firmly into each end to keep the box from opening. When insects are to be prepared for the Riker mount, they should be laid back down upon a smooth sheet of wood or of cork. Their wings should be arranged in the fashion one wishes to see them remain, and pins should be stuck here and there, perhaps through the wings, perhaps about the body. These pins should remain until the body is completely stiffened. This takes from two days to two weeks, depending upon the size and fleshiness of the animal and the dryness of the atmosphere. Before insects are placed in the mount, it is well to lift the cotton and throw under it a teaspoonful of naphthaline, the substance commonly known as tar camphor and used to preserve clothing from moths. This will at least delay if it does not prevent the destruction of your insects by parasites.

Spreading Insects.

Doctor Hodge has recommended a very interesting departure from the Riker mount. He takes a piece of wood, cuts it at the corners so it will bend into a rectangular form as big on the outside as his sheet of glass. The specimens are now touched lightly with glue on the under side, and laid in proper position on a sheet of glass; around these specimens on the edge of the glass the wooden frame is placed and another piece of glass is laid on top of this and the whole is bound together around the edge by a strap of gummed paper. In this way the specimen is placed between two pieces of glass and both top and bottom are equally available for study.

Where this work is not carefully done the insect often breaks loose from the glass. One great advantage of this process lies in the fact that Doctor Hodge has not patented it and has made us all entirely welcome to its use.

76. Such methods as this admit of the formation of many interesting collections. To introduce into such a mount a pressed flower and all the kinds of insects one finds fertilizing this flower makes a very suggestive and beautiful mount. If it is desired to show the separate parts of an insect's body, though this is not often desired for elementary studies, they may be arranged in such a mount and be studied again and again without loss of specimens. A butterfly, the chrysalis from which it comes, the leaf it eats, and the picture of its larva drawn and colored by the pupil in natural size and then cut out, makes another interesting exhibit.

Insect Mounts.

Mounting Spider-webs.

77. I have recently devised a method of gathering and mounting spider-webs which gives me such satisfactory results that I believe it worthy of dissemination. I will describe the preparation, the field work and the final mounting of one web as I carry it out in practise. I take two pieces of glass, say 5 x 7 inches in size. Then I cut four rectangles of cardboard, of the same size as the glass. Out of two of these I cut openings 4 x 6 in size, leaving a half-inch rim. I take with me into the field these four pieces of cardboard tied together with a string, the solid pieces on the outside. With me I also take a tube of white paste. It may be that I have already located a beautiful spider-web which I wish to secure. If this is true, I have, the evening before, with my fingers wiped out the web entirely from the opening. The spider has

Making the Mount.

replaced the snare over night and this morning a fresh new web, not yet punctured by visiting insects, will be found in the same position. Finding such a web as I wish, I untie my rectangles of cardboard, and take one of the open rectangles and spread around one face of it a liberal supply of white paste. This pasted side I press against the spider-web, and with my hand draw the edges of the web, which project beyond the rectangle, over the edge of the card and break them off. The part of the web that comes into contact with the paste adheres quite nicely and with reasonable care the entire rectangle surrounds a beautiful piece of spider web. The other open rectangle is now placed against this pasted side and the fingers drawn around the whole with gentle pressure to make the two rectangles adhere to each other. The two solid rectangles are now laid one on each side of the framed web and a string carefully tied about the whole. Care must be taken not to press the centres of the packed rectangles, for the web itself is sticky and may adhere to these covers. On reaching the laboratory, the string is untied and the two covers of cardboard are gently lifted aside, leaving the cardboard frame with the spider web in the centre. A sheet of glass is now placed on either side of the frame and a strip of binding paper fastens the whole together. The result is a spider-web between two pieces of glass in perfect condition and which can be handled and studied without the slightest danger of injury to the most delicate pattern. The spiders have been so little studied that it would be easy for any diligent person to add much to our knowledge of spider-webs, if he were simply to collect and study large numbers of them, preserving and labelling the accompanying spiders, so he may be sure to know to which spider each web belongs.

SECTION II—THE MATERIALS

VIII

THE INSECTS

78. THE most interesting material for work in nature study is undoubtedly some form of animal life. Animals are more interesting than plants. The movements of plants are so slow, their activity so slight, that life in them seems to be a very different thing from what it is in animals. No other group of animals is so marvellously abundant as are the insects. They swarm everywhere all through the summer. They are easy to catch and easy to watch, and are full of interest. Many of them are very valuable to us, and perhaps more are harmful; so that it is quite worth our while to learn to know them. Of course so extended a group as the insects can only be thoroughly studied in books entirely devoted to that subject. Still there are certain lines of information which are better adapted than others to the work in nature study, and it is these facts particularly to which we will give a general glance. The very name insect indicates one of the peculiarities of its structure; it is cut into sections. The most casual glance at the bee, the butterfly, or the grasshopper, will show us that the body is divided by the neck and the waist into three distinct regions. While it is ordinarily a mistake to use technical terms with young children we shall employ a few in connection with insects, because they are terms which will be used in their study of human physiology.

Insects are Good Material.

79. The three parts of an insect's body are known as

the head, the thorax, and the abdomen. To the head are attached the mouth parts, and the sense organs; to the thorax are attached the parts which produce motion; while the only attachment to the abdomen is the egg-placer, which is sometimes converted into a sting. Let us turn for a time to those organs which produce motion in the animal. The thorax of the insect is divided by grooves into three rather distinct pieces. To each of these pieces two legs are attached, giving the insects six

The Parts of the Insect.

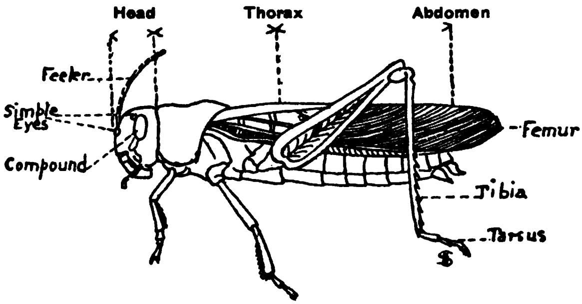

Fig. 2—The Insect's Parts

legs. Each leg has parts to which we will give names, again because the same terms are used as are used in human anatomy. The big joint, close to the body, is known as the femur; the next joint, which is commonly long and slender, is known as the tibia, and then there follows a sort of foot made up of four or five small joints ending most commonly in a pair of hooks. This foot part is known as the tarsus.

80. In much the larger number of insects the legs are simply used for walking, and walking is a more or less temporary means of getting about. The power of flight is so common that most insects walk only for

short distances. The fly will use its wings for making any considerable trips, and only after he has alighted in search of food does he run around in short excursions. There are, however, some insects who travel very largely by means of their feet. The ants, for instance, use this method almost entirely, most of them having lost their wings. Some of the ground beetles can run so rapidly as to make it a difficult matter to catch them, while one of our digger-wasps can use such speed as he darts around for spiders as makes it difficult to keep track of him.

The Use of the Feet.

81. A few insects have taken to a strange form of living, underneath the surface of the water. The admiral beetle, the giant water-bug, and the water boatman, are good illustrations of this habit, and it will be noticed on examining the legs of these animals that they are strangely flattened and serve as oars. With these they drive their boat-shaped bodies over or even beneath the water. The under-side of their bodies is covered with a thin furry coat of hair, among which they manage to entangle a considerable quantity of air, which they use for breathing when they get beneath the surface of the water.

Water Insects.

82. The grasshopper and his close relatives use their hind legs for jumping. These have accordingly become very strong. At the same time these legs are set with short spikes, which help them to catch hold on the ground both in leaping and in alighting. The katydids are even more developed than the grasshopper in this respect, while the crickets, who belong to the same family, have grown short and heavy legs for pushing their way beneath the sod.

Jumping Insects.

83. The method of getting about to which insects are most partial is by means of their wings, commonly four

in number. These, like the legs, are fastened to the thorax. There is almost no other respect in which insects differ more plainly from each other than they do in the shape, texture, and color of their wings, and these differences are commonly used as a basis for separating these animals into groups.

The Arrangement of the Wings.

In some of the insects, the four wings are all of the same size and both pairs of them are used with effectiveness in flight. Dragon-flies, for instance, usually have both pairs of wings very much alike in size and shape. It is found, however, that as we go up the scale in the insect world the wings are inclined to become smaller and to be used with greater rapidity. When this is the case, the hind wings very commonly become smaller than the front wings and are by some means or other hooked to them, usually by a fold along the front margin. In the bumble-bee the hind wing is nearly useless when it is unhooked from the front wing, and this creature will go through strange antics, if you unhook his wings, in his endeavors to get them back into place again. There are many cases amongst insects in which the front wings serve merely as a cover or protection for the hind wings and are not much used for flight. The hind wings in this case must do practically all the work. Any one who has run his hand rapidly along the edge of a blade of grass knows how it will saw. The grasshopper's delicate hind wing would be very soon spoiled were it not that when he is about to alight he first folds his hind wing like a fan and then covers it up with his long hard front wing. While he is in the air, he rather sails than flies, so far as his front wing is concerned. The same is true, in a still greater degree, of the beetles, most of whom keep their front wing entirely motionless during flight. All the work of

driving their bodies through the air is done by the hind wing. As a result, these creatures are very bungling on the wing and they do not fly more than is absolutely necessary.

84. There is one great group of insects in which the hind wings have been greatly changed; they are no longer of any use whatever for purposes of flight and so have entirely disappeared or else have been converted into a peculiar form of organs called balancers. The group in which this has happened is that to which the flies and mosquitoes belong. Almost every one has seen the so called crane-fly sitting on the window. It looks like a gigantic mosquito, with legs two inches long. Close inspection will show two front wings which are rather long and slender and back of them what look like two pins with great round heads and with very sharp points stuck into the insect's thorax. These are known as balancers, and the impression under which the name was given was that they are used as the old rope-walker used a balancing pole, so as to keep the animal from swinging from one side or the other. Later investigation has shown that this is not at all the case but that these are

Two-Winged Insects.

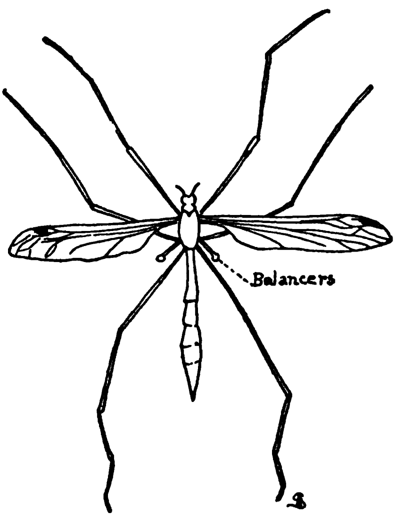

FIG. 3—THE CRANEFLY

organs by which the animal tells whether he is balanced, and in this respect they serve the same purpose for which we use the semicircular canals of the ear.

Sounds Made by Insects.

85. There is a method by which one can determine just how rapidly an insect moves its wings. When any body vibrates regularly oftener than about twenty times per second, there is a resulting hum whose pitch rises with the rate of the vibration. If, then, one has at all a musical ear, he can tell the rate of movement of an insect's wing by the pitch of this sound. If this pitch is middle C of the piano, the rate of vibration is 256 per second; or the C which is an octave below this is 128; still an octave lower is 64. The C above the middle C of the piano is 512 per second, while the second C above the middle is 1024. Knowing the vibrations for C in any octave, the vibrations for any note above C can be easily obtained as follows: D is always produced by $\frac{9}{8}$ as many vibrations as the C immediately below it; E, by $\frac{10}{8}$; F, by $\frac{12}{9}$; G, by $\frac{12}{8}$; A, by $\frac{15}{9}$; B, by $\frac{15}{8}$ as many as the C below; the next C doubles the number. It will be found that the bumble-bee, whose pitch is about E below the middle C, moves his wings at the rate of one hundred and sixty vibrations per second, while the honey-bee waves his wings about three hundred and eighty-four; the fly is still higher, at about six hundred and forty, while the mosquito brings the astonishing record up to nearly a thousand.

86. There are many insects of every different group that for some reason or other have completely lost their wings. The great body of worker ants, for instance, have no wings. There are wingless wasps and wingless butterflies, wingless crickets and very many wingless bugs. It will puzzle the beginner to tell the

group to which such insects belong because, as I have said, insects are classified primarily according to the number and structure of their wings. The scientist has learned by the study of other parts of the body, especially the mouth parts, and by the life history, to tell the group to which these insects belong, but they will often puzzle the beginner.

Wingless Insects.

87. The brain of an insect resembles our brain in little more than that it is placed in the head and that it forms the front end of the double nerve-cord running the entire length of the animal. It is, accordingly, very hard to judge much concerning the mental life of an insect. Of one thing we may be quite sure; it is different from ours, and their action is far more mechanical than ours, and much less dependent upon anything worth calling a will. The eyes are evidently intended for sight though how much they see, or perhaps to put it better, how much the insects realize that they see, it is often hard to tell. Almost everybody has heard that the fly has a "thousand eyes." This is not true in any exact sense of the word. On looking at any insect closely, sometimes by the naked eye, sometimes through the help of the lens, these compound eyes, as they are called, are easily made out. In the dragon-fly they are so large as to make up three-fourths or his entire head and the separate portions, looking much like honey-combs, are large enough to be distinguished without the help of a magnifying glass. On examining an insect it will be noticed that the compound eyes are so rounded that some of the facets point forward, some upward, some outward, and some quite distinctly backward. These are the insect's eyes for seeing things at a distance, and he can look in nearly

The Insect's Brain.

The Insect's Eyes.

every direction without turning around or moving his head.

But, just as many people have two regions in their glasses, one for looking at things at a distance and one for things near at hand, so insects have two sets of eyes, one for far vision and the other for things near by. The set for near vision can be easily found in the case of the bumble-bee or of the grasshopper. Looking carefully in the middle of the forehead between the big compound eyes, there will be seen three shining little spots, two of them above and one below. These are the simple eyes. In spite of all this arrangement for seeing, it is certain that insects as a class see very indifferently. It is evident that bees can see flowers a great distance away, though this seems to be more true of blue flowers than it is of yellow. I think it is also plain that they tell merely the patch of color and that the shape of things is not clear to them until they are very near at hand. I am sure that hornets cannot clearly distinguish flies, which are their usual food, from black currants or even from nail-heads until they get within at least two inches, and even then they often fail to distinguish them until they light upon them. For this reason, it seems as if we must be slow in concluding much as to what it is that insects really see.

The Use of the Feelers.

88. But if it is hard to tell in the case of the eyes just what information insects get from them, it is still more difficult to tell to what use they put the slender, jointed rods which stick out from the front of their head and which are commonly known as feelers. With some insects it is clear that these instruments really are organs of touch. In the ants, for instance, no two ants from the same hive pass without touching each other by means of the feelers,

so that these are seen in their case to be used as some sort of means of communication. These feelers are very different in shape in the different orders of insects. In butterflies, they are long slender rods with knobs at the end of them; in the moths, they are extremely feathery. The commonest form for them to take is that of the series of short joints such as we notice in the grasshoppers or the long-horned beetles. In the

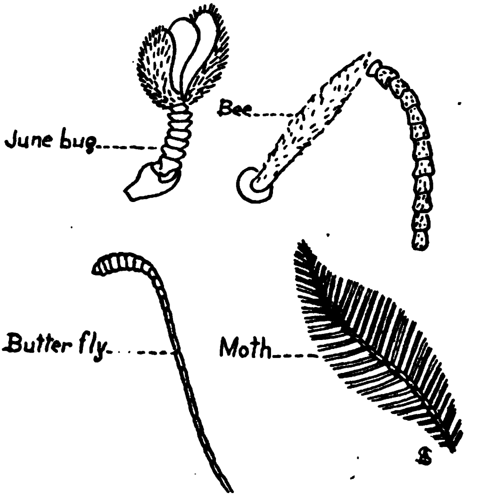

Fig. 4—The Feelers of Insects

bees only one of the joints near the head is long and the others are short, giving the feelers rather the appearance of a flail; while beetles of the June-bug family have three flaps which can be folded over each other or spread like the segments of a fan. While it is true that these feelers may be organs of touch it is very sure that in many insects they are organs of smell. In the case of the ants it has been clearly discovered that different joints in the feelers smell different sorts

of things. This is probably true also in the case of bees, though ants are so blind and live so much by the sense of smell that it is probable this sense is more developed in their cases than in that of almost any other insect.

89. It is difficult to decide in the case of most insects whether they hear at all. Lord Avebury has decided that ants are without power to hear any sound that is within our range. There are organs in many insects which are believed to be used for hearing but they are so very different in structure from each other and are found on such various parts of the body, that it is hard for us to be sure we are right. The best case amongst the insects has probably

The Location of the Ears.

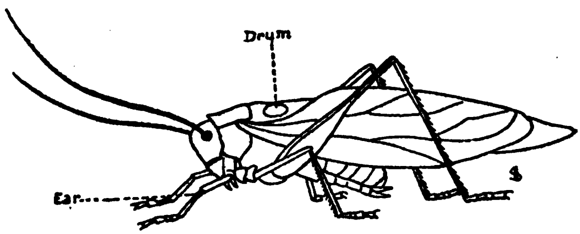

FIG. 5—THE KATYDID

been made out for the grasshoppers and their kind. These insects clearly attract each other's attention by making a noise. Grasshoppers fiddle to their mates by rubbing the inner side of the hind leg against the folded edge of the long top wing. To correspond with this power to make the noise, we have an organ which can catch this sound, and this, in the case of the grasshopper, is placed near the bottom of the side of the last joint in the thorax and is completely covered by the wing excepting when the animal is in flight. The katydids, which are first cousins to the grasshoppers, get their name from their well-known power of singing

to their mates. It is popularly believed that the male sings out the accusation. "Katy-did," to which she is supposed to reply, "Katy-didn't." As a matter of fact, Katy never replies at all; because, in this group, only the males have the power of making a sound and the females are absolutely silent. If you will catch a katydid and it proves to be a male you will find that the left wing, near the thorax and the top of the body, folds over a similar triangular patch on the right wing. In this left triangular fold there is a transparent spot, and on the under side of this is a rib with teeth on it like the teeth on a file. Projecting from the top of the right triangle is a knob which can be rubbed against the teeth on the left file, and by this process the sound is produced. I can make a dead katydid sing the first syllable of its song though I have never succeeded in determining how it changes the position of its apparatus so as to produce the other syllables. The cricket makes his lively night-song to his voiceless mate in a fashion exactly like that of the katydid, and it is interesting to note that both of them have their ears in the same strange place. On examining the front leg, just below the knee on the back of the tibia, there will be found a small drum which has been recognized as the ear of these creatures.

The Biting Mouth.

90. In any animal the nature of the mouth must be very closely adapted to the nature of the food which this creature is intended to eat. Insects are of so many kinds, and the nature of their food and the way they eat it is so varied, that it is not unnatural that their mouths should vary to just the same degree. It is, however, clearly possible to distinguish two great types of the mouth in insects. One of these is the biting mouth, that is, the mouth

provided with jaws which are intended to break off pieces of solid substance. The other type of mouth is the sucking mouth, and is found in such insects as confine their feeding entirely to the juices of animals and plants. In this case, the mouth is always formed into some sort of a tube. Grasshoppers, feeding as they do on the vegetation, and beetles, which eat pollen or young buds or dead bodies of animals, must be provided with jaws. The dragon-flies are insects of prey; they pursue and capture flies, mosquitoes, and such other insects as hover over the water. These, too, must have jaws. The nature of the jaws can be most easily made out by looking closely at the mouth of the big grasshopper or of the big brown beetle. Here it will be noticed that there is, first of all, a front lip. Back of this lie the sharp, strong, shiny, hard jaws which do the real biting and which in some of the beetles are prolonged sufficiently, especially in the males, to give to these insects the name of pinching-bugs. Back of these hard jaws is a pair of soft jaws each of which has on it a small feeler. These help in holding the food to the mouth, so that the hard jaws may properly work upon it. Behind these again is a hind lip, provided with a pair of feelers. These feelers on the soft jaw and on the hind lip are probably provided with nerve tips for gathering information concerning the things which are being eaten.

91. There is another and entirely different type of feeding on the part of many insects. Every one has noticed that the common house-fly has hanging from the front of his head a sort of a trunk, like that of the elephant, and that this is flattened out at the bottom. Any one who has watched a fly feed has seen how this flat end of the trunk is applied again and again to the

material fed upon. Still more interesting is it to watch the mosquito feed. This can easily be done if one will but lay bare his arm and, as a mosquito draws near, place the arm so that he will light upon it. From the lower side of the head there protrudes a sharp organ made up of two shining sides and a sharp central tongue. These sides are worked alternately until a hole is made in the skin. Now the central tongue is pushed down until it reaches the lower layers of the skin and penetrates the capillaries. The pumping motion of the mosquito is very clearly perceptible and the creature can be seen to gradually swell as it becomes gorged with blood.

The Lapping Mouth.

92. Quite as interesting is the mouth of the butterfly. Here a long slender tongue is coiled like a watch-spring between two furry jaws which press lightly on either side of it. It is not difficult without harm to the live butterfly to insert a pin within this coil and unroll this long tongue. It will quickly roll itself up again. If one will notice the butterfly as he approaches a flower it will be seen that he must uncoil this tongue and insert its tip into the mouth of the flower, pushing it down until he has sucked through it the small amount of nectar which has been secreted there. Such mouths as this, of course, must be tubular, but it is interesting to know that scientists have made out that, whatever may be the shape of this tubular mouth, whether it be adapted to lapping like a fly, or to piercing like the mosquito, or to drawing up the nectar like the butterfly, it is still a development of the old mouth, with just the same number of lips and jaws that we found in the grasshopper and in the beetle. But these have been modified by long generations of altered habit until now the mouth has

The Sucking Mouth.

taken very varied forms in the different orders of insects.

93. On looking along the abdomen of a grasshopper it will be noticed that this part of the body is made up of rings and that each ring has a break in it near the bottom of each side. Just above this break there will be noticed a spot nearly like a pin-hole in each of the sections. Through these openings it is that air enters the insect's body. These mouths open into a long pipe passing along either side of the insect's body from head to tail. From these main pipes, branches run to all parts of the body and pass the air directly to whatever organs happen to need it, instead of distributing it through the blood. If one can find one of the big green caterpillars, it will be very easy indeed to see through the transparent skin the throbbing of the heart, which runs the entire length of the back, while at the same time the openings into the breathing pipes can be very plainly noticed in every section of the animal's body.

How Insects Breathe.

94. There is such a wide variety of coloration in animals and plants that it would at first sight seem difficult to find any general principles to account for the distribution of color. But there is a reasonable agreement amongst naturalists that the color scheme of most animals and plants divides itself rather naturally into two sections. This is particularly true in the animal world, where the two great schemes of coloration correspond to two great primitive emotions in the animal itself. The one great overmastering emotion in the animal world is naturally fear. We must not imagine that the life of animals is overshadowed by the sort of emotion that we should feel if we were constantly in great danger. It must

Protective Coloration.

none the less be true that sudden fright and quick action as a result are very common in the life of most animals. Corresponding with this constant danger is a scheme of coloration which naturalists have come to call protective coloration. The animal according to this scheme escapes the danger by being colored so nearly like the surroundings in which he ordinarily lives that, so long as he remains quiet, he is not likely to be noticed by his enemies, and thus he escapes their attacks. The animal himself is doubtless unconscious of his likeness to his surroundings. But nature has worked the scheme for them. In each generation those that are least like their surroundings are picked off by their enemies. In the course of a long time, many of the creatures have come to look very much like the surroundings in which they live.

The Underwing Moth.

95. There often comes into the house, attracted by the evening lamp, a sort of moth whose triangularly folded wings look very conspicuous on the wall where we find it. Next day the gray and brown mottled wings offer a striking contrast with the wall on which he sits, and few people could realize that there is anything protective about the coloration of this insect. If, however, they could see him seated, as he naturally is, upon the bark of a tree, the safety of his color would be apparent. Even when one has seen such a moth settle upon the tree and believes he knows just the spot at which it alighted it is still very difficult to capture this moth with a net because it is so nearly like the bark on which it sits that one can never be quite sure he sees it before the moth flutters away.

96. The katydid, too, is a very conspicuous insect when we have him in our hands or he lights upon a

house. But the katydid is a night-flying animal, by choice, and under ordinary circumstances he rests during the day upon the leaves of the trees. Certainly when the katydid is resting amongst the green leaves it is very difficult to find him. Not only is his color deceptive but the veins in the insect's wings make its resemblance to the leaf very strong indeed.

The Katydid.

97. Many small grasshoppers live upon the grass. These have wings which are colored green like the katydids. Those grasshoppers which are more apt to hop about the ground and down amongst the stems, are very much mottled with gray and red and brown. Every country boy knows the absolutely dirt-colored grasshopper that is so common in the cornfields. When he has once lighted upon the dry ground he is almost indistinguishable. Indeed this grasshopper has a very interesting trick. When he lights upon the ground a watchful enemy would be likely to gather him up were it not for the fact that so soon as he reaches the ground, instead of stopping on the spot where he lights he turns aside for some distance and then remains absolutely quiet, usually face towards you. It is almost impossible to see him under such circumstances. All of these grasshoppers have bright colors about them but, except when flying through the air, they keep them entirely concealed.

The Grasshopper's Color.

98. Few things look more conspicuous than the big green caterpillars when we find them creeping along the pavement, but this is not their natural situation. When they are eating the leaves of the trees upon which they commonly feed none but the practised eye will see them.

Green Caterpillars.

99. The protection that can come from coloration is often aided by the form of the animal itself. No animal could illustrate this more clearly than does that peculiar insect sometimes known as the walking-stick. In this insect, a long slender body with attenuated legs has every appearance of being a twig with dry branches projecting from it. I think there can be little doubt that the above explanation truthfully accounts for the coloration of a very large number of animals.

The Walking-Stick Insect.

100. There is more discussion amongst naturalists as to what is the part that brilliant coloration plays in the animal world. I believe there is a fair agreement amongst scientists that the action of attractive coloration, of which we shall now speak, is valid in the case of the birds. There are very many naturalists who doubt whether insects show any tendency to select their mates by particular preference. It if were necessary for the insects to think about the matter, or even to know that they had the preference, I should be slow to imagine there is any such thing as selection of the mate in the insect world; but I believe that the whole process is utterly unconscious but none the less effective even amongst insects.

Do Insects Care for Colors.

101. The bright coloration, then, probably corresponds to the emotion of attraction in animals, just as the protective coloration corresponds to the emotion of fear. While a dull color will help an animal by allowing it to escape its enemies, a bright color will be very valuable to it in attracting a mate. As between two butterflies of the same kind it seems not unlikely that the brighter and fresher fly, other things being equal, will be more certain to win a mate, and thus more likely to hand on bright color to its off-

Attractive Coloration.

spring. Thus in generation after generation the brightest insects succeed best in the critical process of winning a mate. As the duller flies fail, gradually most butterflies have come to be brighter colored.

Attraction versus Protection.

102. It will be noticed at once that these two principles of coloration are contradictory to each other. Dulness of color hides from the mate as well as from the enemy, and brightness of color is just as effective in showing up the presence of an insect to its foes as to its friends. Accordingly, we see a constant struggle between these two forms of appearance. Dragon-flies, for instance, are so rapid on the wing and themselves so ferocious that they can afford to be bright colored without serious danger. In the case of the beetles the hard shell is a very considerable protection and these too are often bright colored; but, whenever there is unusual brilliancy, it is very apt to be the case that these creatures are very quick in their movements or have an unusually disagreeable odor and probably flavor.

Attractive Butterflies.

103. It is amongst the butterflies that we find the most remarkable colors in the insect world. These beautiful creatures feed upon the nectar of flowers and so it is not difficult for us to imagine that their eyes have learned to discriminate between colors. If, then, there is such a thing as selection of mates amongst butterflies, it is not hard to understand that color would largely be the basis of selection, and hence we can understand the brilliant hues which cover the wings of the butterflies. But these creatures are very defenceless and would be in great danger were it not for the fact that they fly with a very jerky flight, never moving for any considerable distance in any one direction. This makes it very difficult for birds, which

are their natural enemies, to catch them while they are on the wing, and when they rest the butterflies have a habit of folding the wings erect and in such a way that the thin edge of the wings only is noticeable to the bird flying above them. If a bird should look at them from the side while they are sitting upon a flower, it is a remarkable fact that he would see a far duller set of colors on the under side of the wings, which are now exposed, than covers the upper side of the wings, now concealed by their being placed against each other.

104. There are a very few insects which can afford to be bright colored without danger, because they themselves have a sting for their defence. This is the case, for instance, with the wasps and the bees, many of which are brilliant in color and the sting is so formidable a weapon that these bright colors can be safely carried. Indeed some naturalists believe that such cases as these may be properly called warning colors, because by them other animals clearly recognize the species, at least after a little experience, and pass them by.

Warning Colors.

105. There are few classes in the animal kingdom which have so many enemies as have the insects. They often prey upon each other. Dragon-flies shoot about, picking up almost any flies or insects they see above the marshes. The killer-fly darts swiftly along the open road, pursuing and plunging his cruel beak into his weaker captives, while the hornets hover around picking up flies and the digger-wasp goes picking spiders off of the flat sheet webs. But this makes a small part of the insects that fall a prey to voracious enemies. Birds apparently eat more insects than any other class of animals. Swallows skimming over the meadows and the waters pick

The Enemies of the Insects.

them up by the thousand. Woodpeckers dig their grubs out of the decaying wood of the tree. Fly-catchers, fluttering down from their open perch, pick them from every sunny field, while the meadow-larks and the partridges, not to mention our domestic fowls, keep gathering them in. A smaller portion fall a prey to many of our snakes, the garter-snake being particularly active in this respect and often not eating much else. Toads live very largely on insects, eating great numbers of them, these and snails being their particular food. When by any chance a fluttering insect drops into the water, the more he struggles the more certain he is to be picked up by the fish. Even some of our smaller mammals such as the mole and the bat find not a little of their food in this group. With such great numbers of enemies it is not unnatural that insects should be provided with various devices to aid their escape. The main provision against being wiped out is undoubtedly the fact that insects multiply very rapidly. I suppose one hundred eggs would not be a large average in the insect world, and in many species there may be three, four, or even five generations within a single year. Hence the natural rate of multiplying is sufficiently rapid to insure a good chance of survival. Many of the insects move about with such great rapidity that they readily escape their enemies. Such is the case with very many of the flies whose flight is so very rapid and even so jerky as to make them difficult to capture. I have little doubt that the same result is often secured by the habit, which many insects have, when they hover in the air, of not staying strictly in one place but instead of raising and lowering their position, though it be only for a few inches at a time. Sometimes these insects hover in small circles. All these methods make

it exceedingly difficult for swallows or fly-catchers to capture them.

106. The beetles are covered with so hard a shell that they often escape where other insects equally large would readily fall a prey. Birds that catch dragon-flies and pound them to pieces for their young could do little with beetles of anything like the same size. Not a little of protection comes, as has already been said, from the great resemblance in color and sometimes in form between many insects and the background on which they habitually live. Still another efficient means of protection is found in the sting and often in the nauseous odor, these insects doubtless tasting as bad as they smell. This bad odor is very common in the group known as the true bugs. The squash-bug is very offensive. There are not a few amongst the beetles which are very ill smelling. It is very remarkable how few of the insects have even the faintest power to poison by the bite. Popular stories to the contrary notwithstanding, the one really severe weapon at the disposal of almost all insects is the sting, and this is found only amongst the bees or wasps and a few ants. The rest of the insect world is without power to sting. There are repeated stories of the stinging power of the cicada, the so-called locust, but they are all false. It is very easy to find the rather large organ believed to be the sting but it does not sting. The sting of an insect is always a modification of the egg-placer and for this reason must of course be confined to the female. In the group of insects mentioned above, the ants, bees and wasps, the egg-placer is often sharpened to a fine point and provided with a gland which secretes the irritating fluid introduced into the wound. This fluid, by the way, is almost always acid and its irritating power is readily neutralized by a

Insect Defenses.

drop of ammonia promptly applied to the wound; in the absence of ammonia, baking soda with a little water will answer nearly as well.

The Dragon-fly's Eggs.

107. There are some of the lower forms of life living in the water that multiply with enormous rapidity, but with the exception of these, insects probably surpass the rest of the kingdom. This is partly because they lay so many eggs and partly because in many cases three weeks will cover the whole life history of an insect. In a long and dry summer there may be many broods. The eggs of insects are commonly laid on or near the food on which the young are to live, and the eggs once laid the mother in most cases pays no further attention to them whatever. It is interesting to watch a dragon-fly laying her eggs. She hovers over the surface of the water, curls down her abdomen, suddenly plunges the end of it into the water and promptly draws it out again, making a little splash. Each time the abdomen penetrates the surface of the water an egg is protruded. If this were dropped upon the surface of the water it would swim away, but inasmuch as the mother has pushed it under the surface, the egg slowly sinks to the bottom.

The Butterfly's Eggs.

108. Butterflies will often be seen flying industriously from plant to plant, alighting not upon flowers but upon the leaves themselves. They then usually creep around to the underside of the leaf. In such cases it will be ordinarily found that the butterfly has deposited its eggs, to which it will pay no further attention and from which the young caterpillars in due time will emerge. It is interesting to see how many species of butterflies confine their egg placings to a single kind of plant or to a very restricted number of plants. Our common brown monarch butterfly con-

fines its attention to the milkweed. The black swallow-tailed butterfly places its eggs on the members of the parsley family, while the presence of the zebra swallow-tailed butterfly may be taken as sure evidence that somewhere not far away one may expect to find a paw-paw bush. I think sometimes the same butterfly varies in this respect in different parts of the country. The larva of the promethea moth feeds both upon the spice bush and upon wild cherry, but I think in Pennsylvania, west of the mountains, it prefers the wild cherry to the spice bush, while in southeastern Pennsylvania the spice bush certainly has the preference. The nile-green moth with long slender tails, properly known as the luna moth, deposits its eggs chiefly upon the hickory, and the same is true of the imperial moth, a splendid light red-brown moth with a yellow dashing through the wing. The larva of this moth has a most ferocious appearance. Its many back-curving horns and its habit of apparently viciously darting at anything that touches it have gained for it the formidable name of the horned hickory devil. The common house-fly for the most part deposits its eggs in the droppings of horses and cows, and the presence of a stable or of uncovered manure-piles near a house is sure to result in large numbers of flies. The shining metallic blue fly hunts around for dead flesh in which to lay its eggs, and meat intended for food should be always carefully kept away from the possibility of visitation by these flies.

The Fly's Eggs.

There are two interesting groups of insects closely related to each other that are very interesting in this respect, the gall-fly and the ichneumon-fly. These are lowly members of the great bee order. The gall-flies deposit their eggs in the tissues of growing plants. The egg thus introduced soon yields up its young larva. For

some reason or other the presence of this egg or of this larva produces irritation in the plant and causes an unusual growth at this point. The little red horns that stick out of the maple leaves are such galls. The large gray balls filled with powdery hair so common about oak trees are produced in this way. The golden-rod often has swellings of this sort in its stem, while throughout the northern part of our country the tips of the small willows that grow by our streams often bear what looks like furry gray pine cones.

The Gall-fly's Eggs.

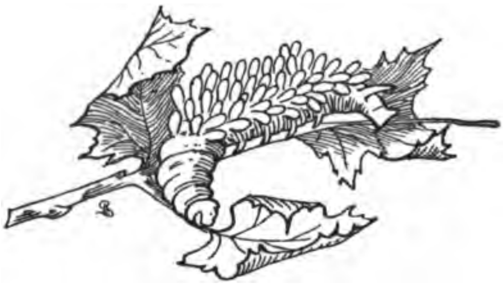

FIG. 6—THE ICHNEUMON FLY'S COCOONS

In every case a cut into the heart of these structures will show the presence of the animal within. Ichneumon-flies are more heartless in their habits; they lay their eggs inside the bodies of caterpillars. Any one who grows tomatoes will probably have noticed a long, green, so-called worm, with a horn on its tail. This is really the larva of the five-spotted hawk-moth. Late in the season it is not uncommon to see these larvæ look as if they had little rice grains pasted over the sides of them. The truth of the matter is an ichneumon-fly has punctured the skin of the back of one of these caterpillars with its egg depositor, running down into the flesh of the creatures twenty-five or thirty eggs. These eggs develop and the young

The Ichneumon-Fly's Eggs.

that emerge feed upon the fat and connective tissue of the larva and, when they are ready to transform into adult ichneumon-flies, each eats its way through the skin of the larva to the outside, and spins over itself its silken case, making it look like a rice grain. These cases drop to the ground, and later yield up the adult ichneumon-flies, while the larva, robbed of all its stored nourishment, dies.

109. To one who is not familiar with the subject of insects it would be a very difficult matter to foretell what sort of a creature is to come out of the eggs. Of course we understand that in time the creature will come to look like its parents, but there may be no resemblance whatever between the young thing and that which it is to be. A grasshopper looks in most respects much like his parent. But no little fly ever gets to be a big fly and no big fly ever was a little fly. A fly is a maggot until it has its full size, and it does not become a fly until it is as large as it ever will be. The same is just as true of the beetle and butterfly, the mosquito or the bee, and of many other insects. Few people realize that the so-called worm in the chestnut is the young of a beetle whose mother has placed the egg in the puncture which she had made in the growing bud. This larva has grown up in the chestnut and when it is full grown will eat its way out of the nut and burrow into the ground, on which the nut is then lying. It will there pass through its resting stage and will come forth a beetle like its parents, ready to puncture fresh chestnut blossoms.

The Two Kinds of Development.

110. Every teacher probably knows that caterpillars turn into butterflies, and many a school child has watched the spinning up of the larva of one of the big moths into its silken cocoon, and later

Caterpillars.

has been delighted to see the beautiful moth come out of the case.

111. Backboned animals have their skeletons on the inside of their bodies, and there is enough animal matter

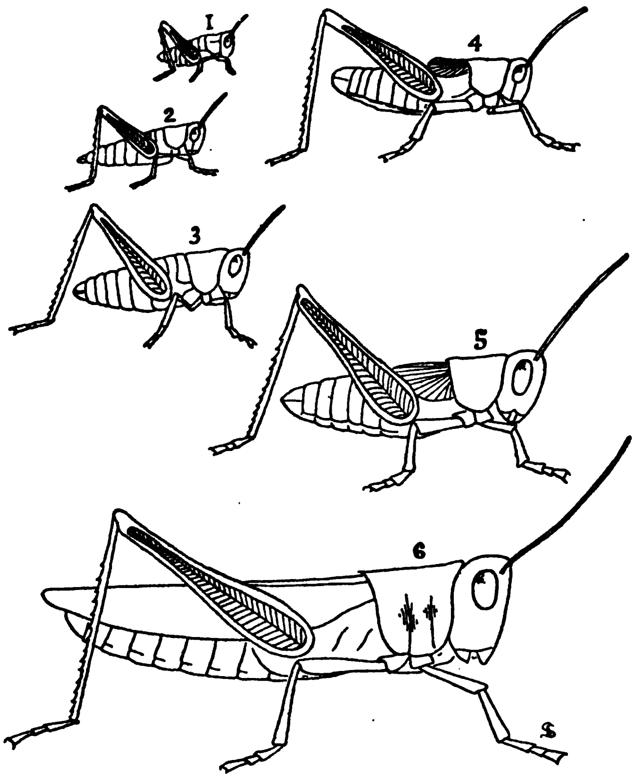

FIG. 7—THE GRASSHOPPER'S LIFE HISTORY

in them to make it possible for them to grow as long as the animals grow; but the insect's skeleton is upon the outside and is practically dead. A young grasshopper finds it impossible to increase in size. By

eating persistently he only succeeds in packing himself tighter on the inside and he must soon feel a sense of great pressure. Under these circumstances, it must be a relief to him to find his skin split across the neck and down the back. Out of this opening the insect creeps, leaving the old shell behind. For a few hours his new skin allows him to grow very rapidly and then hardens once more. He again eats and again packs himself most tightly in this larger skin, when it splits and he emerges, once more to grow for a few hours. This process repeats itself at intervals of a week or so. After six emergences, our red-legged grasshopper has attained its adult form. In all these stages he is readily recognized as a grasshopper, although it is only in his last stage that he has usable wings.

The Growth of Insects.

112. This process of casting the old skin is quite as regular in caterpillars as in grasshoppers, and these creatures must molt again and again, their color often changing with each molt. All the growth the butterfly gets is crowded into its caterpillar life, and there are not a few butterflies in which there is no food taken after the caterpillar life closes.

Casting the Skin.

113. There is a very general supposition that caterpillars are not safe to handle and that they irritate if not poison our skin. I have handled very many of them and I know but two that are very irritating to handle even to the most sensitive skin. The larva of the Io moth is one of these. It is a green larva with a purple band along the side and is covered with sharp knobs which bristle with pointed, stinging hairs. This larva is found most commonly on the corn, and if it comes against the tender parts of the flesh it produces a very decided swelling which burns rather severely. Even this caterpillar has no power to

Irritating Caterpillars.

penetrate the tough skin of the palm side of the hand, and if handled very carefully may be handled safely. There is another larva known as the saddle-back which is more irritant even than the Io. This is a little caterpillar, rectangular in shape, bright green in color, with an oval dark spot in the middle of its back which gives it the name. This little fellow is tufted with short

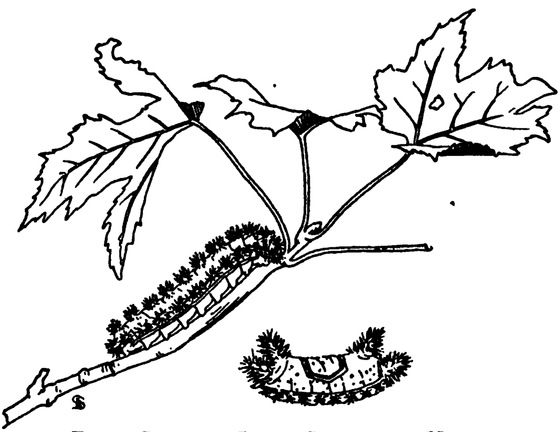

FIG. 8—LARVÆ OF IO AND SADDLE-BACK MOTHS

and bristling hairs which have in them a very irritating secretion. This larva, too, may be handled in the fingers if care is taken to prevent it from touching the delicate parts of the hand. I believe these are the only two of our common caterpillars which produce any unpleasant effect. The rest of them may bristle with horns and may dart savagely at you when you touch them but they are entirely without power to do harm.

114. In most cases the young insect looks utterly unlike its parent. This emerging insect grows rapidly and still looks no more like the adult form. Often its food is altogether different from that of its parent,

and at the same time its method of locomotion is absolutely different. Under these circumstances it is necessary that the animal should undergo a change. While this change is taking place it is practically impossible for it to either move about from place to place or to take food. Accordingly there has been interposed between the larval and adult stage a strange resting form known as the pupa. Taking our most familiar example, the butterfly, we find that since emerging from the egg in the shape of a little caterpillar, this creature has been growing rapidly, and shedding its outer skin at short intervals. When it has grown to its full size, it retires to some protected spot and hangs itself up by a silken strap from the tail or about the shoulders. Throwing off its last caterpillar skin, it now looks entirely unlike either the caterpillar it was or the butterfly it is to be. As it hangs here in this strange form, its internal organs practically melt away; buds spring from the inside of the body wall and gradually grow to become the legs and wings of the approaching butterfly, all still snugly packed up inside the pupa skeleton. At the same time the digestive organs are completely transformed. It was the habit of the caterpillar to eat leaves and such like material. The butterfly is to gather nectar, which is practically sugar water, through a long and slender tongue. Such utterly different food implies a difference in the organs which deal with it. The horny jaws of the caterpillar must give place to the slender tongue of the butterfly, while the internal changes are nearly as far-reaching. This change may take place quite rapidly, especially if the weather be warm, and a week or at most two may suffice to transform the caterpillar into a butterfly; but should the weather be cold, as will be the case late

Insect Transformation.

in the summer, the transformation is likely to stop, and the pupa, as this stage is called, will be the form in which the insect passes the winter. As spring ap-

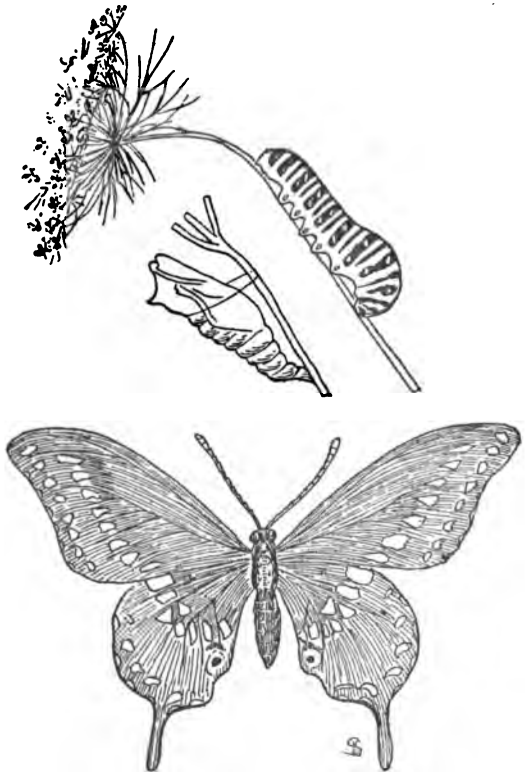

FIG. 9—THE BUTTERFLY'S LIFE HISTORY

proaches the process begins afresh and the internal changes are completed. The return of warm weather brings out the butterfly.

115. No less interesting is the case of the common hawk-moth. This, it will be remembered, is the name

The Cecropia and its Cocoon

applied to the adult fly whose long larva infests tomato and potato vines. It is the larva with the horn on its tail. When the time comes for this insect to transform, instead of hanging itself up, as the butterflies do, it burrows into the ground and there makes itself a little room in which it passes through its change. This is the odd brown creature with a tongue like a pitcher handle, which the plow so often turns up in the old potato- or tomato-patch. **The Hawk-Moth.**

116. The true moths, at least those of the spinner groups, instead of hanging themselves by a few threads, or of burying themselves in the ground, make for themselves very interesting silken cases. Any one who finds one of the big caterpillars and pens it up in a box with a glass lid, will be interestingly rewarded. **Cocoons.** The caterpillar must be fed the sort of leaves to which it is accustomed. Fresh and tender material must be supplied each day. After the animal has eaten all he cares for, and can not be tempted with new food, all of the leaves should be taken from the box. The caterpillar now begins to roam about the box, leaving behind itself constantly a silken thread which gradually covers all of the walls of the box. Then threads begin to be spanned across the box and grow more and more abundant, until the accumulating silk completely conceals the caterpillar from view. Long after this, he may still be heard working inside the box. After a day or two of this work all is quiet, and the caterpillar has gone into his pupa state. This silken covering of the pupa is known as a cocoon. Sometimes it is made entirely of silk; sometimes the caterpillar uses leaves with the silk. But the case usually consists of an outer wall, a loose fluffy layer beneath this, and within a tough inner lining, all being of silk. This case is absolutely

waterproof, and cold seems to have no terrors for these creatures. They undoubtedly freeze stiff in winter time, but when spring comes they seem to be no worse for their experience.

117. The mosquitoes are amongst the most interesting of the insects in this matter of development. The female insect after mating lights upon the surface of the water to lay her eggs. It is said this process goes on usually in the early morning before sunrise; personally I have never seen it. The female deposits flask-shaped eggs upon the surface of the water in such a way that the eggs stand upright and adhere to each other, forming a packet that may be a quarter of an inch long and one-eighth of an inch wide, and contains probably one hundred and fifty eggs. In a comparatively short time (the length depending upon the temperature) the young larvæ emerge from the lower end of the eggs and swim about freely in the water. At this time they are so small as to look as if the vessel in which they are being reared has been wiped with a cloth, which left lint upon the surface of the glass. But this fine lint soon proves to be the young mosquito larvæ and they lead a most active life. These are the "wrigglers" so common in every country rain-barrel. Sometimes they are pumped up from a cistern. Every now and then one of them comes to the surface of the water, and sticks the tip of a side branch, which springs from near the tail, up to the surface of the water. This side branch ends in a rosette, which can be opened or closed when the creature reaches the surface. He opens the rosette and takes air into his breathing system, closes the rosette and jerks rapidly away through the water. Meanwhile his jaws, which are beset with tufts of hair-like attachments, are working with a con-

The Life History of the Mosquito.

stant, whirling action, which forces into his mouth the small green plant matter, microscopic in size, which floats freely through the water. In a couple of weeks, these wrigglers will have cast their skin a half dozen times if the weather is warm, and at the last casting will come out utterly transformed in appearance. Now a large and rounded head has a slender body attached to it, while from its upper end, two horns project. This is the pupa stage of the mosquito, and its habits of life are altogether different. He no longer eats. His movement through the water is different in character; before this, he was heavier than water and unless actively swimming seemed to settle to the bottom. Now, unless he is actively at work, he floats regularly at the top, his two horns serving instead of the rosette near the tail to admit air to his breathing system. In this stage the transformation of the internal organs

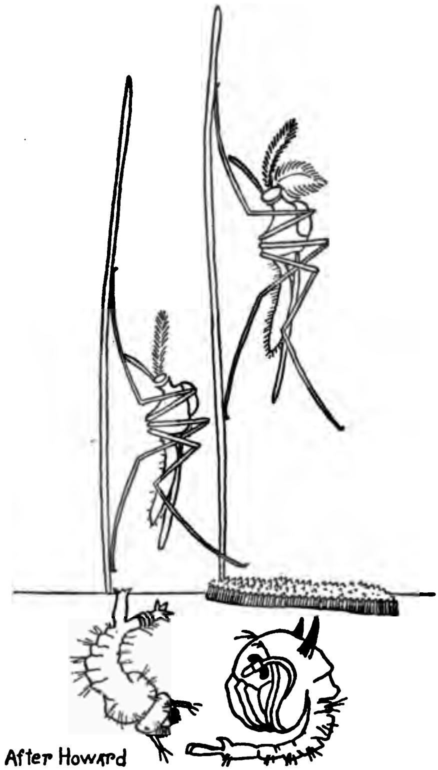

FIG. 10—THE MOSQUITO'S LIFE HISTORY

goes on, and when this skin splits there emerges from it the adult mosquito. When this is to happen, the pupa floats close to the surface, its skin splits down the back, and out of the opening the full-fledged mosquito slowly pulls itself. It stands for a moment with expanded wings on the floating pupa-case and then relinquishes it to try its new form of life. So long as this creature is in its larval or pupal stage it seems to bear freezing with impunity. The water in which these wrigglers live may become a solid cake of ice and yet when it thaws they seem quite as active as before.

Insects in Winter.

118. The adult lifetime of many insects is only a day long; a week is a considerable life for many more, a few months is old age, and only now and then is there a rare species in which the adult lives for more than a year. These exceptions are chiefly in the group containing the ants, the bees, and the wasps. Amongst such members of these groups as store up food for the winter, the length of life is sometimes greater. Lord Avebury tells of an ant queen which he kept for fourteen years. But a large proportion of insects spend but a short adult life and pass the winter either in the egg or in the pupal condition. There is an interesting difference between the honey-bees and the bumble-bee in this respect. A colony of bees consists of one queen, who is a female capable of laying eggs, of many males capable of fertilizing a queen, and of large numbers of workers. These last are often spoken of as neuters, as if they had no sex, but as a matter of fact they are undeveloped females who lack the power of laying eggs. In the case of the honey-bee, a hive in winter time will contain one queen, thousands of workers, and hundreds of larvæ or pupæ which will not be adult bees until the following year. The case of the bumble-

Bees in Winter.

bee is entirely different. A female bee is fertilized in the fall by a male, which promptly dies. The female lives over the winter in some out-of-the-way cranny, and in the spring starts a new home for herself under the ground or in a hollow fence rail. Here she makes a few nearly spherical cells, puts into them a syrup mixture of nectar and pollen, and deposits in this mixture a number of eggs. From these eggs emerge males and females who relieve her from all further work except the laying of eggs. They build the comb, make the honey, and feed the young. This process may continue until the fall, when the colony may contain a hundred or more bees. It will die out completely in the winter, only a few fertile females living over until the next year. Each of these may start a colony of her own when spring returns.

The Mating of the Insects.

119. The principal mission of the insect during its adult stage seems to be that of securing a mate and depositing its eggs in an appropriate position. It is for this purpose that the grasshopper leaps into the air with quivering wings. It is for this that the katydid, hiding by day quietly in the recesses of the trees, comes out at night and fiddles its plaintive lay to its attentive mate. For this the butterflies chase each other, doubling and pursuing one another, circling about each other and displaying to the utmost advantage their exquisite coloration. It is for this that the queen bee makes one of the only two trips in life that take her away from the hive.

120. To most ant-hills there comes, perhaps twice in a year, a great wave of weddings. In all the little hills of the same species in any neighborhood, the impulse seems to arise at the same time. Out of these hills come the winged ants, the males being smaller and

much more numerous. A female, after wandering around a little, flies up into the air. She will be followed by several males from adjacent nests, with one of whom she mates. The males die within a few days; the fertilized female pulls off her wings, gathers about her a few workers, who are always wingless, and starts off to swell the ranks of an old colony or perhaps to found a new colony of her own.

The Mating of the Ants.

121. We have long known that the honey-bee was the friend of man, that is to say, we have understood that this little creature will gather and store the nectar and manufacture it into honey, in quantity far beyond his own needs. We have known very well that we can rob the hive of a reasonable amount of this delicious substance and still leave enough for the maintenance of the brood until the following season, when more can be gathered. But it is only within comparatively recent times that we have learned to appreciate their labors quite independently of any honey which they produce. Bees are very helpful to the flowers, and hence by indirection to ourselves. It is highly probable that our apples, pears, plums, peaches, and other fruits would give us but very little return indeed were it not for the kindly offices of these creatures, The bees wander around over the blossoms, carrying the pollen from one to the other. Our grapes, too, would bring us but a slender crop if it were not for these busy creatures. In this beneficient work, the bumblebee is scarcely, if at all, behind his better known friend, the honey-bee.

Helpful Insects.

122. It is a well-known fact amongst farmers that the first crop of clover each year contains very little seed, and that it is from the second crop that the great bulk of the seed must be obtained. The reason for this is

that when the first clover blooms, the newly-started bumble-bee colonies are as yet so small that very few of the clover heads succeed in becoming fertilized, but by the time this crop is mown and the second crop appears, the bees have multiplied and are now abundant. Busily they probe the flowers of the clover, and the result is a large crop of clover-seed. The honey-bee will not answer for this work, because his tongue is too short to reach to the bottom of the long red clover-blossoms. It is the white clover whose far shorter flowers are best adapted to the visits of this little friend.

Bees and Clover.

123. In this work of carrying pollen from flower to flower, the butterflies are also quite active, but their long and slender tongues are adapted particularly to those flowers whose corollas are developed into narrow deep tubes. Hence it is that the butterflies serve rather those flowers which we admire for their beauty than the blossoms whose fruits we eat. We are quite practical enough to be far more thankful for the fruit and the clover than we are for the flowers.

Butterflies Carry Pollen.

124. Sometimes perhaps in going through the country you have inadvertently turned up some small dead animal. From underneath it there scurried away a crowd of ill-smelling flat beetles, whose presence in such a disgusting situation excited your contempt. It is loathsome to think of an animal eating the decaying body of another animal; but if dead animals lay around until the ordinary process of decay had carried them away, this earth would be a much less pleasant place in which to live.

Insect Scavengers.

125. Every one has noticed that no sooner is raw meat exposed in the summer time than it immediately

attracts considerable numbers of a shiny blue-green fly. Our first thought would naturally be that this insect comes to suck the juices of the meat, but its errand

Blue-Bottle Flies.

is a double one. While it is feeding it may at the same time deposit its eggs over the meat and these eggs soon begin to develop. From them emerge little maggots, which eat their way into this flesh until the whole may become a quivering, swarming mass of maggots. Few sights are more disgusting, and yet this action of the maggots is a most wholesome one, indeed, for the blue flies do much to keep the atmosphere of the earth free from the reeking taint of putrid flesh.

126. There is one group of insects whose advantage to us is an entirely indirect one. They help us, not by doing us any immediate good, but by helping to free us

Ichneumon Helpers.

from our enemies. I have spoken of the horn-tailed larva, so common on our potato and tomato vines. A closely allied form is about equally common upon our catalpa trees; still another infests our grape vines; while a fourth is very destructive to the hops. The ichneumon-fly, which hovers over these destructive creatures, and inserts its eggs under their cringing skins, has of course no thought of ridding us of our enemies; but the service is as valuable as if it were directly intended for our benefit. As a matter of practical inference, it will readily be seen that when one is clearing such worms from his vines he should be careful never to remove a worm which has the little objects which look like rice grains plastered over its body. We may be quite sure these larva will never produce more of the same kind, and we know that the ichneumon-flies which lie within these apparent rice grains had far better, for our purpose, go through their development and come forth to sting other larvæ.

127. It is the bright side of the picture at which we have thus far been looking. If we are earnestly desirous of doing so, we can manage to find a comparatively small number of insects which are useful to man, but the number of insects whose interests run counter to those of man is very much larger. Insects as a group are very apt in their growing stages to feed on vegetable material. They are so abundant and grow so rapidly that they manage to consume an enormous amount of food. The plants which man cultivates have been so sheltered as a result of cultivation that they have become more tender as a rule than the wild growing trees and herbs. Few grasses are probably more sensitive than wheat; few wild nightshades are so tender as the potatoes; few forest trees so delicate as peaches. For this reason, cultivated plants are more liable to be attacked by insects, and more liable to succumb to their onslaughts. It is almost impossible to imagine how much loss comes to man from this cause. Occasionally a new insect is introduced; it sweeps across the areas occupied by a plant, and often produces such enormous damage as to make us clearly understand how much money is thus lost; but there are probably hosts of insects in whose absence we could raise such crops as we have never dreamed of. The grasshopper tribe are responsible for a very large proportion of our losses. The Hessian-fly destroys very large amounts of wheat by weakening the stalk, and after the wheat is gathered the Angoumis moth injures a great deal more. This loss is increasing so much that farmers are coming to thresh their wheat and sell it as promptly as possible before the moth can multiply, thus saving much of the wheat, but losing much in price which might be obtained for the wheat

Harmful Insects.

Enemies of Wheat.

if it could be held. If it were not for the birds, which feed so steadily upon insects, our loss would be very materially greater. The movement for the protection of the birds is no mere matter of sentiment; it is a matter of the preservation of our crops.

128. Everybody is familiar with the small "worm" often found in the apple. This is the larva of a small dusty moth known as the codling moth. When the apple was in blossom a moth of this kind fluttered around, depositing its eggs in the now forming fruit. The larva emerged from the egg, punctured the ovary of the flower, and has since been growing there.

The Codling Moth.

FIG. 11—THE APPLE MOTH

It is now nearly ready to pass into the pupa stage; so when the apple falls from the tree, the worm makes its way out and finds a safe spot. Here it remains until it has transformed into the adult codling moth, which is now ready to deposit its eggs in new blossoms. Any farmer who realizes this life history can easily see how foolish it is to allow the apples which fall from the trees to lie upon the ground. For here the larvæ can creep out and develop, adding to the loss which the farmer has already sustained. If these apples were picked up and fed to the hogs or crushed into cider, a part of the value of the apple would thus be secured and the codling worm destroyed.

129. The fruit-grower has of recent years suffered much from the San José scale. The scale insects are very abundant, and often infest fruit trees, but the

well known kinds have been working upon our trees so long that they seem to have become accustomed to them, and no longer suffer so seriously from their ravages. But the new scale introduced from China, by way of South America and California, is putting to the test all the skill of the careful grower. Scale insects are really small creatures, not distantly related to plant lice. They insert their tongues through the thin bark of the young twigs and suck the sweet juices of the plant. Unlike the plant lice, when once they have inserted the beak, they never withdraw it. Meanwhile a waxy substance, which has been sweating out of their backs, has been melted into a shield which completely covers them. These creatures multiply very rapidly, having many generations in a season. It is no uncommon matter, when they have once been introduced upon a young peach or pear tree, to have them kill the tree within three or four years. Any ordinary grower of fruit trees, who finds the San José scale on any of his trees, is evidently foolish if he does not promptly take measures to remedy the trouble. If but few trees are infested, it would be far better to chop them down and burn them than to do nothing, though such desperate remedy as this, ought not to be necessary to the careful fruit-grower. The oyster-shell scale and the scurfy

Scale Insects.

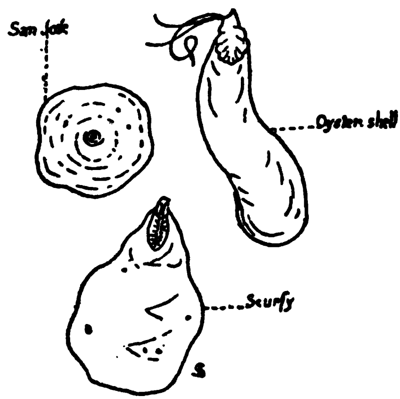

FIG. 12.—SCALES COMMON ON FRUIT TREES

bark louse are far more common but much less dangerous.

130. The common house-fly has been always looked upon as a nuisance; but it is only of recent years that we have come to realize that it may become a very bitter enemy. It was part of the dear knowledge purchased by the loss of many lives in the concentration camps at the outbreak of the Spanish war. Typhoid fever was abundant in some of these camps. Typhoid always comes by infection, and as the infection must come from the intestine of a typhoid-fever patient one is always infected by contamination from sewage, either directly or indirectly. Most commonly it is the drinking water which serves as the medium for infection. Perhaps next in frequency is infection from milk. Recently oysters found in the mouths of our rivers have proven a serious source of danger. But in these camps, the flies transferred typhoid-fever germs from the open trenches to the mess kitchens and in this way infected hundreds of soldiers. Two lessons are plain. The excreta of a typhoid-fever patient should always be disinfected before being thrown anywhere, and kitchen windows and doors should be well screened to prevent the entrance of flies.

The House-Fly and Typhoid.

131. One of the most interesting relations between insects and disease has been worked out in recent years. So long as the mosquito was simply a nuisance we put up with him. But when once we began to understand that he was not only a nuisance but a menace, the war against the mosquito began. It used to be believed that malaria, as the name implies, was due in some way to bad air. A swamp was particularly objectionable because of its power to produce malaria. It is of course well known that

The Mosquito and Malaria.

swampy regions are undoubtedly malarious, but the swamps are only indirectly responsible for the malaria. The real source of the danger is the mosquito, whose larva swims in the swampy water. This mosquito cannot of itself give malaria, but it can become infected from a malarial patient and give it to a new subject. Malaria is caused by a parasite, which is a very lowly form of animal, and which lives within the red corpuscle of the blood. A particular kind of mosquito sucks the blood of such a patient. If it were now to go directly to another person and bite him, this would be without effect, for the malaria is not transferred directly to the new subject. The mosquito must live for a few days and in the walls of its stomach there will appear a pimple-like swelling, in which the malarial parasite is passing through a different stage of its existence from that which affected the man. When this swelling has run its course it bursts, and the multiplied forms pass into the blood of the mosquito, thence to its salivary glands, and from here they are introduced into the next person bitten. Therefore it is that the mosquito not only transmits, but is the intermediate host between two cases of malaria. Since this discovery, the warfare against mosquitoes has been continuous. This is especially true in the extreme south, in tropical countries,

Fig. 13—The Malarial and the Common Mosquito

where another species of mosquito is responsible for the dissemination of yellow fever.

132. If it is desired to rid a region from mosquitoes, three methods may be employed. First, and best where possible, the pool in which the larvæ live, may be drained of water. This of course is the end of the mosquito. But it must be remembered that the mosquito larvæ are small, and that an old tin can or a hollow tree stump is sufficiently large to breed them abundantly. All such places must be thoroughly cared for. Second, if draining is too serious a matter, the pool of water may be freed from its mosquitoes by pouring a little kerosene upon its surface. A teacupful of oil once in two weeks will suffice for a pool twenty feet square. Where neither of these methods is desirable (as, if one has an artificial lily-pond), a very effective remedy is to keep goldfish or sunfish in the pond. These feed eagerly upon the mosquito larvæ, and will serve readily to free the pool. Not all mosquitoes can transmit malaria. Our commonest mosquito, called Culex, does not do so. It is the kind named Anopheles which does the work. These two may be distinguished from each other by the fact that when the Culex stands upon a surface he keeps his body parallel to the surface; while Anopheles tilts the rear end of his body high up into the air. Culex has wings that are entirely transparent, while Anopheles has two dark-colored patches across each of his wings.

Banishing Mosquitoes.

133. The spider is not an insect, but will be conconsidered in this section because of its near relationship to that group. The spider has been too much neglected in study, for the natural reason that he is popularly supposed to be exceedingly dangerous. It seems impossible to realize that almost if not all the

dread of the spider's bite is without reasonable foundation. It is becoming clearer day by day that the amount of venom in the bite of a spider is, for our common spiders, so absolutely small as to

The Spider.

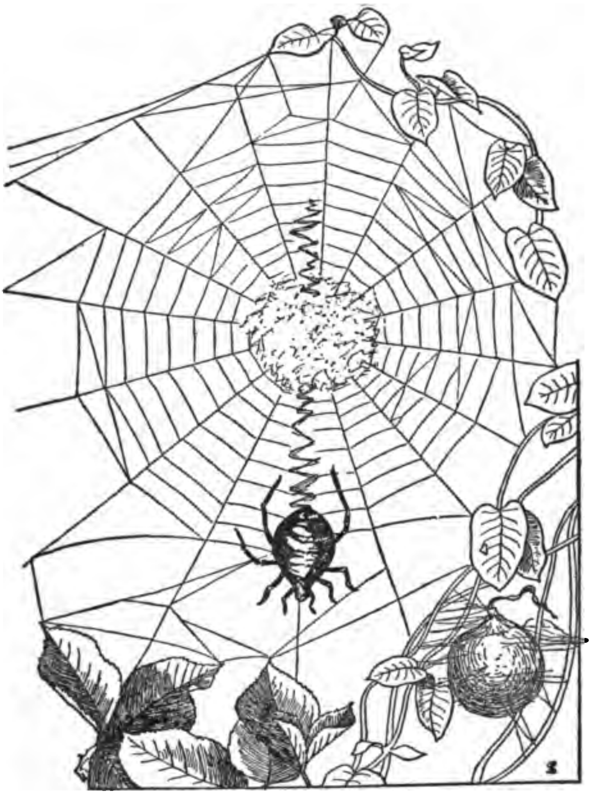

FIG. 14—THE BANK SPIDER'S WEB

be entirely without effect on people. I have been repeatedly bitten by spiders, occasionally of very consider-

able size, and never has there been the faintest sign of swelling, even so much as would be produced by the bite of a mosquito. As a matter of fact, spiders are ordinarily timid and make very little attempt to bite at all. There are two quite varied habits in the spider world in the matter of securing food. A large number of spiders run about, hunting their prey; these are active, have strong legs and rather large and sharp jaws. A few of them, when teased, will leap at and bite the finger. The members of the other great group weave webs, and count on this method for catching the prey. Amongst this group there is an aristocracy which builds webs of unusual beauty. These are the orb-weaving spiders. They are the spiders which spin beautiful webs in which a spiral snare is run around a foundation of radiating threads. A close examination of such a web will reveal the fact that the central platform and the radial threads are dry and on these the spider may run and rest with impunity; but the spiral thread is a sticky thread and is intended to capture the prey. This thread is quite as apt to adhere to the spider as to his prey, and the result is that the spider learns to keep his feet carefully off his own sticky threads. A little search about the outside walls, in the late fall or winter, will disclose little silken packets, inside of which are bunches of salmon-colored eggs. From these eggs emerge the most cunning spiderlings, which will run about over everything, leaving behind them slender threads, by which they possibly find their way back to the nest during the first few days. Another form which the egg case may take is that of a sphere, nearly an inch in diameter, with an opening at the top like the short neck of a bottle. This will be found in the fall, hung up in the branches of a weed,

The Spider's Web.

amongst a network of spider-webs. These cocoons will yield considerable numbers of spiders in the early spring. Most of these come to maturity at the expense of their less valiant and less vigorous brothers.

IX

SOME WATER DWELLERS

134. In describing the aquarium, mention was made of the pond snails. These little creatures are very abundant and can be found creeping over the rocks and grass and plants in most of our smaller streams. Scarcely any creek running through the meadows is without them, and often the dams have many pond snails. They are exceedingly interesting to watch and very easy to keep. Ordinarily the shell is about one-half inch in diameter and is dark brown in color. It is wound into a spiral, which ends in a rather blunt point. The snail can withdraw himself completely into the shell and when he does so is well protected from most of his enemies. When transferred to the aquarium, the pond snail rapidly protrudes himself from his shell. The whole under surface is entirely flat and is pressed against the surface on which he moves. As he walks up against the side of the aquarium it is easy to watch the under side of his foot. Watch it closely as one may, it is hard to realize, excepting in the most general manner, how it is that he manages to slide along. One of the strangest feats of his locomotion is that he can creep up the side of the aquarium

The Pond Snail.

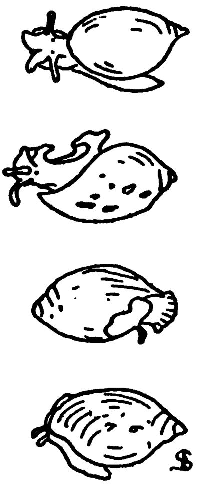

Fig. 15—The Pond Snail

until he reaches the surface of the water and then turn outward and creep along the under side of the upper surface of the water, If we may so speak, he is distinctly able to progress without the aid of any material to hold on to, on the under side of the surface of the water. In front of his foot is his head, which looks, on the under surface, as if it were a part of his foot, cut off only by a narrow line. It is as flatly pressed against the surface on which he walks as is the foot. In its centre is a mouth, whose lips open sidewise instead of up and down as do ours, and as he walks over the side of the aquarium he cleans from the glass whatever deposit of green vegetable matter may have formed there. His method of cleaning this material is very interesting. It is as if the tongue had rows of many teeth, running across its surface, and making it resemble a file. If while our mouth be slightly open, the tip of the tongue is pressed against the back of the lower teeth and kept there, the body of the tongue being meanwhile thrust out of the mouth, we will have a very close imitation of the method by which the pond snail rasps his food from off the surface over which he is traveling. Turning to the upper side of the snail, we find the large shell lying on top of his back. There is a tall slender hump on the back which runs up and twists around into the shell so that the live snail never comes entirely out of his shell. The little things often called snails which are seen about gardens and which have no shells are really slugs. The head has short pointed fleshy feelers sticking out of its upper surface, while at their base we find a pair of small dark eyes. This particular group of pond snails differs from most snails in the manner of breathing. When they want air they creep to the surface of the water, turn over on their

The Snail's Tongue.

sides and open a hole about the middle of the right side in such a position as to draw in air. The opening then closes like the mouth of a bag except that it does not pucker and the animal, now having a fresh supply of air, goes again about its business. Whenever the aquarium wall is clean, the pond snail travels over the surface of whatever vegetable matter may be in the aquarium and slowly cleans it off, even rasping into the tissues of the plant itself.

The Fresh-water Mussel.

135. The fresh-water clam or mussel was referred to in the section upon the aquarium. This creature is so much slower in all its activities than the pond snail, and keeps itself so entirely in its shell, that there is really not very much for the children to observe about him. When taken out of his position in the bed of a stream, he quickly pulls both shells together, squirting out at the same time a small amount of water. If this creature be placed upon the bed of stones and sand in the bottom of the aquarium, he will lie absolutely quiet for a considerable time, then his shells will very slowly begin to separate, but they will not open very far. By the time they have opened three-eighths of an inch he can push out through the slit a tongue-like, fleshy foot. By the aid of this foot he can very slowly and gradually turn himself on edge and drag himself down amongst the stones, until he has completely buried himself, with the exception of a small portion just back of the point of the hinge which fastens his shells together. With this part protruding above the sand, he opens the shell a very little and if one looks carefully into the slit he will notice that the two thin frills, much like those around the edge of an oyster, are held together in the middle of the opening, while toward either end of the opening the lips of these

frills separate. If a fountain-pen filler be filled with water that is a little dirty and then be held near this pair of openings and the dirty water expelled gently out of the fountain-pen filler into the water of the aquarium, the floating particles of dirt will easily make clear the fact that there is a current of water running into the opening that is farthest from the hinge, while a similar current of water is passing out of the portion of the slit nearest the hinge. It will readily be seen that the dirty water is drawn into the mussel through the one opening but the water that comes out of the other opening is beautifully clear. It is this sort of floating dirt which ordinarily contains not a little of plant or animal matter which serves as the food for the mussel. If one cares to wade into shallow ripples where the water is six inches deep, and look carefully, he will have no great difficulty in seeing the open slit of the siphons of the buried mussels. In an aquarium these creatures need no food. What small amount of food they really require comes to them from the sediment stirred up by the other creatures moving about in the aquarium.

Circulation Through the Mussel.

136. The crayfish is one of the most interesting of the dwellers in the aquarium, and in some respects one of the most satisfactory. Few other water dwellers will interest the children so thoroughly and few will better repay study. The crayfish is a rapid consumer of oxygen. In his natural haunts he prefers rather rapidly running and shallow water, as this furnishes him with his desired air supply. When we come to pen him up in an aquarium where there is no motion of the water, and where oxygen comes only from the exhalation of the plants, it is very frequently the case that there is not sufficient oxygen for him and

The Crayfish.

he dies of suffocation. His flesh decays with great rapidity. Consequently, as soon as one sees a crayfish lying on his back in the bottom of an aquarium, the presumption is that he is dead and he should be very promptly removed or he will foul the water. When one wishes to capture crayfish, the best plan is to take a net very similar to the one used for butterflies. If this is held on the bottom of a stream, some distance below a number of small stones lying on the bottom, and some one then disturbs these stones, it will often happen that the crayfish will be stirred up and washed down stream into the net. Indeed I find for such purposes that a very satisfactory net can be made by taking a rectangle of mosquito netting about a yard long and three quarters of a yard wide, and fastening it securely at either end to sticks a yard long. This leaves a part of the stick for the handle at each end, the narrow edge of the mosquito netting being fastened to the sticks. This very simple contrivance in the hands of an agile boy, who has with him a companion, who will stir up the water a yard or two farther up the stream, will furnish a great deal of material for the aquarium, including many things which will probably take the

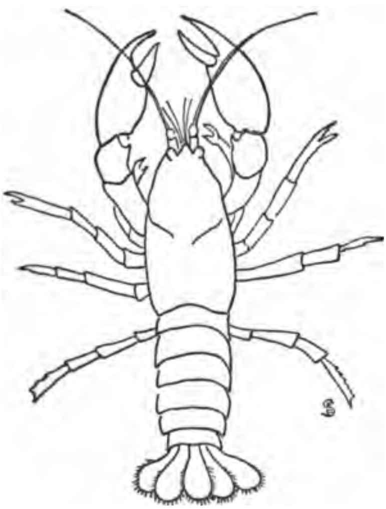

FIG. 16—THE CRAYFISH

teacher some time to identify. Returning to our crayfish we notice that he is practically a diminutive lobster living in the fresh water. The head and back of the crayfish are in one continuous piece, a slender point running out in the front like a ram on a battleship. From the front of the creature's head projects a pair of slender organs, each of these having two whip-like branches. These are known as the small feelers. If one examines closely the bottom joint on each feeler close to the head he will find on the side of it a sort of semi-transparent window. This is the ear of the crayfish. It is quite possible, however, that the crayfish does not hear. Everybody knows that we hear with our ears; not so many people are familiar with the fact that we tell the position of our heads by our ears and that our sense of balance, by which we keep ourselves adjusted so as not to topple over, has its location in the semi-circular canals of this organ. Any disease of this portion of the ear produces dizziness instead of deafness. It is quite certain that the ears of the crayfish are such organs of balance; but it is not clear whether they also hear. Just back of the small feelers are the long feelers. These, when unbroken, can be turned backwards and touch the tip of the tail. Close to the base of these feelers we notice the eyes, which are set in a fashion very different from our own, for they stand out on the ends of stalks and can be rather freely moved. On the under side of the head is the mouth. The great brown covering over the back of a crayfish does not extend across the under side, but ends in a loose edge as if the creature had on a jacket which is not buttoned down the front. Underneath this jacket along either side is a series of gills, looking not unlike ostrich plumes. The water must be

The Organs on the Head.

drawn over these gills. Near his mouth is a pair of fan-like scoops which can be whirled most rapidly by the crayfish, producing a very distinct current in the water. The water enters at the back and under edge of the jacket and passes out at what would be the collar. Perhaps nothing the crayfish does will be discovered with so much zest by the children as this rapid twirling of the gill-bailers, as they are called. To see it, one must get low enough to look under the front end of the crayfish, as he stands on the bottom of the aquarium, facing the observer.

The Gills

137. A crayfish of very considerable size can pinch just about hard enough to give a sensitive person a slight sense of discomfort. I have never seen one pierce the skin of one's finger and a child who has once allowed himself to be pinched will have no hesitancy about letting it happen again. The crayfish of our smaller streams, when full grown, is about four inches long, though in the rivers they often grow larger. The shad-net on the Delaware, in addition to bringing in shad, brings in crayfish by the hundreds and here one can often find them of considerable size. The tail ends in five broad flaps which make a very efficient propeller. The crayfish walks quietly on the bottom of the stream so long as he is undisturbed; but once frighten him and a rapid flap of his tail sends him shooting backwards through the water and he runs into some cranny, from which his swinging feelers and swaying eyes search about in quest of the enemy who has so seriously disturbed him.

The Claws.

138. About the best method of feeding the crayfish is to take a piece of raw meat about an inch long and about one-half inch wide and thick. Wash this carefully in water, kneading it between the fingers, until all

the juices are thoroughly washed out and the meat looks pale. Now tie it to a piece of string and let it hang into the aquarium. Leave it here for perhaps two hours and then remove it. Do this once a week and your crayfish will probably get along well enough. If the meat is not thoroughly washed, or if it be allowed to remain in the water too long, bacterial pollution of the water will be sure to result and this is very difficult to remedy.

The Food of the Crayfish.

139. The crayfish is like the insects in the fact that its skeleton is on the outside and will not grow. Accordingly at intervals the shell splits and the crayfish turns himself out of the crack in the back, leaving the old shell behind. In this condition he is so soft and tender that it seems as if he must fall apart. He is unusually shy and timid at such times, for he is of course subject to much danger. This method of casting the shell is common, too, in crabs and lobsters, and it is the common crab, just after he has thus cast his shell, that is sold in the markets as a soft-shelled crab. Forty-eight hours earlier he was a hard-shelled crab; forty-eight hours later his shell will be fairly hard again.

Casting the Shell.

140. Fish are the most satisfactory animals in the aquarium. With a reasonable amount of care, if the fish are not too abundant, they thrive perfectly well and are easy to observe and very interesting. The key-note which will transfer a careless observer into a thoughtful one, is the idea that the fish are back-boned animals like ourselves and the two pairs of fins are similar in origin, and to some extent, in structure, with our arms and legs. This early study in comparative anatomy should be only the beginning of a habit which the thoughtful student of nature will develop all his life, a habit of finding the kinship be-

The Fish.

tween the creatures of the animal world about him and himself. It will early be seen on watching the fish that his broad fan-like tail is his main means of propulsion.

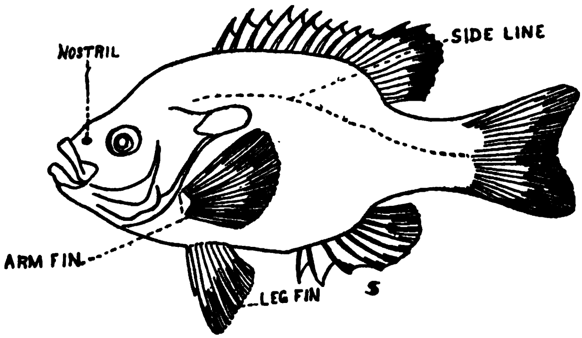

FIG. 17—THE SUNFISH

Up from his back and down from his under surface stand certain fins stiffened with spines, but these do not help him along as much as keep him straight. But it will be noticed by the careful observer that there is a pair of fins on the side of the body just back of the head, and that there is a noticeable independent movement of these fins, both of which may work at once or they may move separately. These may be called the arm-fins and are truly related to our arms, though developed for a different purpose. Further back is another pair, in most fishes not so active, but separately movable as were those at the shoulder. These may similarly be called the leg-fins as they correspond to our legs. The frequency with which a fish opens his mouth, when there is nothing in the water in front of him, will easily indicate that he has some other purpose than the taking of food for which he constantly uses it. It will be noticed that there are circular slits just back

The Fins of the Fish.

of the head and these open when the mouth does. These end the gill covers and under them lies a set of organs which serve the fish as lungs serve us, that is, to bring the blood into contact with the oxygen. Whereas we take the air into our lungs, in the case of the fish the water first dissolves the air and then the gills take the oxygen second-hand from the water. While it is true that water is a compound of hydrogen and oxygen, these two are linked together so forcibly in water that no animal can separate them. Accordingly it is only such oxygen from the air as becomes dissolved in the water that the fish and other water inhabiting creatures can use. The constant movement of the mouth which can be noticed in the fish serves to carry the water into the mouth and down into the throat. Here it passes through slits in the side of the throat over the blood-gorged gills and furnishes to them their supply of oxgyen, taking from them meanwhile their excess of carbon dioxide. The nostrils of fish accordingly are not used for breathing as are ours. They are only organs of smell and they are like a fountain-pen filler into which water may be drawn up and out of which it must be forced from the same opening. The water is retained long enough for the fish to catch any odor that is in it and then expelled. These nostrils are not very large but there is no difficulty in finding them. An interesting point which pupils do not always notice is the fact that there is considerable mobility about the eyes of the fish. They are not tightly fastened in their sockets but can be moved from side to side, somewhat as ours are, though by no means so freely. In almost all of our fishes there will be noticed a very distinct line along the side of the body. This is so common that it must have some very

The Gills of the Fish.

The Fish's Nostrils.

distinct and important purpose. The most likely explanation is, that it serves the same purpose as our semicircular canals, that is, that the fishes by means of this line are conscious of the position and balance of their bodies.

The Side Line in the Fish.

141. Fish, at least in the aquarium, are rather indolent and are of course cold-blooded, and consequently they need very little food. A little soda cracker or some similar biscuit or a tough crust of bread put into the water for an hour or two every third day and then removed, will give them all the food they need and perhaps more than they care for. Here as before care must be taken to remove all the unconsumed food from the aquarium, or it will spoil and the water of the aquarium get sour.

Feeding Fish.

142. In many of our little streams as well as in the damp grass and in the damp space beneath stones it is very common to find a little creature which children usually call a lizard. It is a mistake, for lizards love the dry sunny spots and have scaly skins. These newts could not live twenty minutes in the open sun on dry ground. There is a common opinion that it is dangerous to drink by putting the mouth to a spring because of the great likelihood of swallowing one of these newts. If this should happen, the only result would be the digestion of the creature, of course to his detriment, but with no harm whatever to the man who swallowed him.

The Newt.

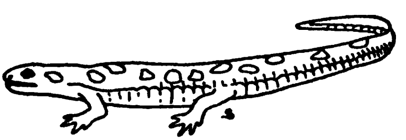

FIG. 18—THE SPOTTED NEWT

X

THE FROG AND THE TOAD

143. The frog and the toad form two of the most interesting animals that can be used in nature study. Both of these creatures are very abundant and very easily obtained, and both of them thrive in captivity. At first a frog will interest the children more because most persons have had instilled in them at a very early age a repugnance to the toad, which is as senseless as it is amusing. Amongst the Pennsylvania Germans there is a belief that the killing of a toad, by a man, makes the cows which he owns give bloody milk. Nowadays when one is pressed to give his reason for his hatred of the toad, the reply is very apt to be that it produces warts. Of course this is nonsense. I can only conjecture how the wart story came to be associated with the toad. Doctor Edward Eggelston, in one of his delightful historical essays, tells us of a belief common among our colonial ancestors which was known as the doctrine of signatures. According to this notion, the Creator has shaped the leaves of a certain plant to look like a kidney, in order that we might know that He intended us to use it for curing diseases of the kidney. This plant we call kidneywort. Liverwort and lungwort were shaped, so the belief tells us, like the organs named, so that we might use them for the curing of diseases of these organs. I suspect in similar fashion it was supposed that the wartiness of the toad was given

The Prejudice against Toads.

Toads and Warts.

to it by the Creator as a warning to us so that we might know our danger of acquiring warts if we handle the animal. In truth this appearance is a part of the great scheme of protective coloration, and helps to make the animal less conspicuous as it lies quietly on the irregular surface of the ground. The wartiness of the toad serves him for protection just as the green of the frog serves to make him less conspicuous as he lies concealed in the green scum of the pond.

FIG. 19—THE TOAD

144. The shape of both of these animals is exceedingly suggestive. The front legs are very small and weak and serve as little more than props to keep them from falling flat upon the ground. It is in their great hind legs that their power of locomotion chiefly lies. These legs have grown stronger generation by generation, until these creatures, instead of running like the newts and salamanders from whom they are descended, take great leaps whenever they wish to escape from danger, or when they wish to travel any considerable distance. The frog is far the more rapid of the two in its movements. He rarely carries as much fat about him as does the toad, and his legs are longer, so it is really a very difficult matter to run after and capture a frog. But the toad is heavier in body and lighter of legs and depends far more than the frog on his protective coloration and on the fact that in the daytime he rarely roams abroad. It is only after sunset that the toad really becomes active and the

The Big Hind Legs.

greatest delight in watching him must always come from watching him in the evening.

145. In both of these creatures the eyes are very prominent, standing well out of the head. If one lightly touches the top of the eye it will be withdrawn into the head until it is level with the surface. Each eye can be withdrawn separately as can each lid be winked separately. There does not seem to be the same coördinated action between the two eyes as we regularly find in many of the higher animals and in people. This power to retract the eyes is a very valuable one. The eyes protrude from the head so that the frog, while living in the water, can see some distance over the water without having anything more than the tip of his nose, with the nostrils, out for breathing and the eyes for seeing. Under the circumstances, especially if there be green plant material floating in the pond, he can be practically invisible. But when the frog is sitting on the bank and on the approach of danger suddenly dives into the water and even into the mud on the bottom of the pool, his eyes would run serious risk of injury were it not that they can be withdrawn level with the rest of the head. The toad's eyes are capable of being withdrawn like those of the frog, though it would seem as if there was not the same advantage to him as there is in the case of his water-loving relative. But the toad was once a frog and still lives like one for a few weeks in spring and it may be that there is sufficient advantage in this peculiarity to make it worth retaining even in the new life of the toad.

The Eyes.

146. Mention was made of the nostrils of these creatures. These nostrils lie near the top of the head and a very little observation will show that they open and close constantly while the creature is breathing. The

toad has no ribs and no diaphragm and must rely on other methods than ours for his breathing. His nostrils communicate with the back of the mouth, and by opening these nostrils and pulling down the skin on the under side of his chin the mouth can be filled with air. The nostrils are now closed and the chin pushed up, thus forcing the air down the windpipe into the lungs. When the nostrils are again opened the elasticity of the lungs forces the air out and the cycle of respiration is complete. This constant opening and closing of the nostrils, accompanied by the moving of the chin and the swelling of the walls of the chest, all in perfect rhythmical fashion, is very interesting to watch.

The Breathing

147. The ear-drums of the frog are very conspicuous. They lie some distance back of and below the eyes and are circular discs on the outside of the head. The external part of the ear, which is so prominent in us, is entirely absent from most animals below the mammals. The toad's ears are not quite so conspicuous as are those of the frog, and neither of them gives much evidence of being acute in the sense of hearing; although it is very hard to tell whether this is due to lack of sensitiveness in the organ or whether it is, as I think more likely, a question of brains. These creatures are not very quick in their reaction to any stimulus which is not fairly strong.

The Ear-Drums.

148. The toad's method of feeding is exceedingly interesting. It can often be watched under any electric light in a small town. The tongue is arranged in an altogether peculiar manner. While most animals have a tongue which is loose in the front and attached at the back, just the reverse is the case in the toad and the frog. Here the

The Method of Feeding.

tongue is attached to the front of the mouth and points back toward the throat. When the toad wishes to catch his food, which is usually an insect, he hops rather slowly toward it, or indeed if it approaches him he often sits quiet until it gets near. When this insect has reached a point within an inch or an inch and a-half of the toad, the tongue is suddenly protruded, as if one were to throw his fist from his shoulder with elbow raised, until the arm was straight and then bring the fist back promptly to the shoulder. The whole process is so quickly carried out that unless it be closely watched it will not be seen. The toad has one distinct advantage over his frog cousin. Over certain ridges of his back is located a series of glands which can pour out, or indeed at times to shoot out with considerable force, a fluid like milk in appearance, and intensely bitter. The taste of the secretion is so unpleasant as to deter many animals from attacking the toad. For some reason or other the toad does not always use this means of defense, and I have come to suspect that it is particularly active in the females in the mating season. At this time many young lives are tied up with the life of the mother, the eggs not yet having been laid. It is not unusual for nature to be more than ordinarily careful of the life of her young creatures.

The Protective Fluid.

149. There is almost no phase of nature study that will interest pupils more than the development of the toad or of the frog. In spring both of these creatures deposit their eggs in the pools. Early in April the "peep, peep," of the Pickering frog starts the appearance of the frog family, and all through the month and into May the process continues. Frogs and toads of all kinds now go to the water; during the rest

The Voice.

of the year the tree frogs and the toads may live far from the old home, but during the spring the ancestral longing comes on and they all return to the water. As the eggs are deposited by the female they are fertilized by the males. With the eggs there is secreted a thick mucus, which swells in the water until the eggs are converted into a thick mass of jelly. The bull-frog will lay a cluster of eggs which when the jelly is swollen in water will make a double handful; the spotted frog will lay a good handful of eggs, while the egg mass of the Pickering frog is about as big as a green walnut. The toad is a more highly developed creature. Instead of turning her eggs loose in a single mass, she distributes them in a slender string, moving about the pond constantly as she does so. By this means she entangles them in the grass in such a way as to make it unlikely that any current flowing through the pond, in case of high water, should carry the eggs away to destruction.

The Eggs.

The Development of the Frog.

150. If the eggs of the frog be closely examined, it will be noticed that they are dark on the upper side and light on the under side. This light-colored material is largely fat and weighs more than the dark part of the egg. By this means the dark part, from which the frog eventually develops, is always kept on top where it will receive light and heat. If the egg mass be turned upside down, it will be but a comparatively short time before each embryo, as the forming animal is called, will have righted itself again and the whole mass shows the black side of the egg on top. If such egg mass, whether of the toad or of the frog, be brought into the house in a vessel, which will hold a considerable amount of the water of the pond, there will be little difficulty in having the tadpole hatch.

The toad eggs will develop far more rapidly than those of the frog and for this reason are more interesting. The toad eggs are black all over and very much smaller than those of the frog. They lack the large amount of nourishment which is present in the frog's eggs, and this is for an interesting reason.

151. When any animal passes from the egg to the adult stage, there are two sorts of changes through which it must go. We are very apt to confuse these two processes because they go on at the same time, but they are entirely distinct. One of these is growth, and this means only increase in size. At the same time, in most animals, there goes on what we know as development. By this we mean increase in complexity and in power, consequently, to meet the varying demands of surrounding circumstances. The toad gets his development very rapidly and consequently looks like a toad when he is very small. After this he gets his growth. A frog, on the contrary, grows for a long time without very much development. Accordingly he gets very large before he looks like a frog.

Growth and Development.

152. To return to the egg; if the black spot in the egg be watched day by day it can be seen gradually to change its shape. After a while an oblong ridge lies over the egg. Shortly the head and tail separate themselves, while the centre part of the body remains attached to the food mass in the egg. This food mass grows smaller while the toad daily grows larger, and soon the creature wriggles in the egg. It will not be long now before the young toad will break the membrane, pass out of the egg and swim freely in the water. At this time close observation will show a pair of fringes on either side of the neck. These will

The Use of the Yolk.

likely be mistaken at first for front legs, but in reality they are external gills. Into them the blood of the toad steadily flows, in order to absorb oxygen from the water.

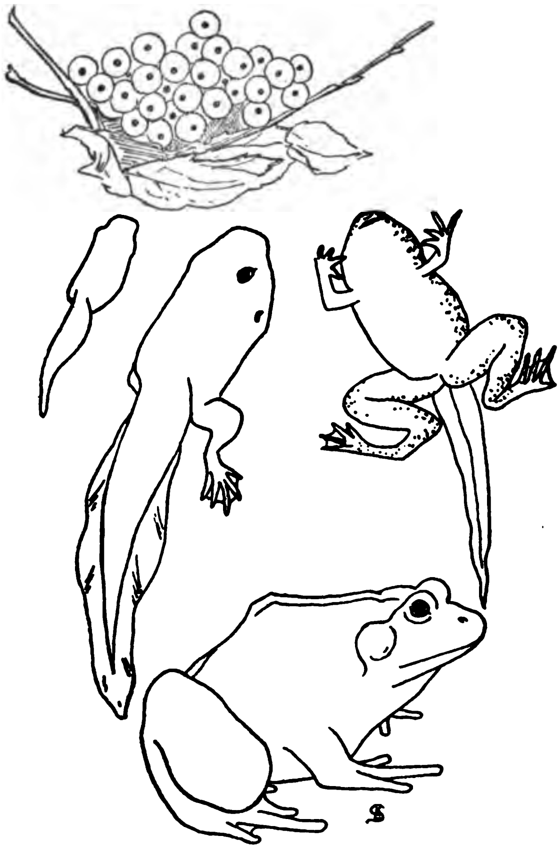

FIG. 20—THE FROG'S LIFE HISTORY

These gills, however, are soon withdrawn into the neck, after which water must enter the mouth and flow out of the opening on the side of the animal to pass over

the gills. Meanwhile near the root of the tail, the hind legs break out and some time later the front legs appear. Under the best of circumstances many of the tadpoles will die by this time. In those that remain, the tail will gradually become smaller, being reabsorbed into the blood and the material being used to build other parts of the body. After the first few days, tender vegetable matter must be fed to the young tadpoles. A lettuce leaf or a piece of cabbage bruised between the fingers and thrown upon the water seems to satisfy them very well. Later on they need animal food, though bread crumbs or fish food seem to answer. If not too many dead tadpoles are left lying in the aquarium so that the water becomes foul from their presence, the survivors seem to have no objection of feeding on the bodies of their dead brothers; which is clearly an economical method.

153. It is interesting to notice how common is the habit amongst the members of this group of singing a love song. It is sung entirely by the males, and varies very much in character among the different members. The "peep, peep," of the Pickering frog has already been mentioned. The great "more rum" of the bull-frog is well known to those who live in the country. The little leopard frog says "chung," but the toad has the only gentle voice of them all. It lacks the insistence of the frog's, but for musical quality it surpasses most of the voices of the spring, even including those of the birds. I hardly know how to describe it; but if one can imagine a creature purring through an unusually soft and melodious flute he will have some idea of the sweetness of the love song of the toad.

The Spring Song.

XI

THE REPTILES

154. THERE is no subject in the whole range of nature study on which there will be so wide a variation in the feelings of both the teacher and pupils as in the matter of snakes. We have two injurious snakes, the copperhead and the rattlesnake, and in regions where these are found it is well that every child should know and avoid them. But both of these snakes are getting comparatively rare and in thickly-settled regions are entirely absent. Even close to our large cities other snakes are reasonably abundant. No fear and no repugnance is more entirely without foundation than this widespread hatred of the snake. Of course the third chapter of Genesis is the reason commonly urged for our dislike of the snake; but in fact this dislike is older, in the Teutonic race, than their acquaintance with the Bible, and was present in other races to whom the Bible was unknown. It is an exceedingly early antipathy and one that has not yet been accounted for. Certain it is that snakes are practically harmless so far as any of the species found north of Virginia are concerned, with the two exceptions previously mentioned. To this list the water-moccasin and the coral-snake must be added in the South. It is of course true that when captured snakes will bite, but the teeth will rarely more than just penetrate the skin. The young teacher may count it for certain that some time or other some boy will bring a snake to school, and he had better be prepared for this emergency. For

Snakes.

Venomous Snakes.

him to be scared is what the boy has hoped, but if he rises quickly to the situation he will have gained a new power over his school. It is not particularly necessary that he should handle the snake, although it would be better if he did, and the knowledge that the creature is harmless and that if caught just back of the neck it cannot turn to bite, will help to give the teacher courage. The rattlesnake and copperhead can be distinguished from other snakes by several points. Of course the rattles of the rattlesnake are distinctive, but there are other points which serve quite as well to separate these snakes from the non-venomous kinds. In the first place, the great distinction is that there is a pit between the eye and the nostril as if the point of a blunt lead pencil had been forced into the head. This gives to these snakes and their other venomous kin the name ofthe pit vipers. All of the poisonous snakes of North America and most of those of the world are pit vipers, while no harmless snake in America has this pit. Again, our venomous snakes have scales on top of their head, scarcely larger than those which cover the rest of the body, while in the non-venomous snakes these scales are much elongated.

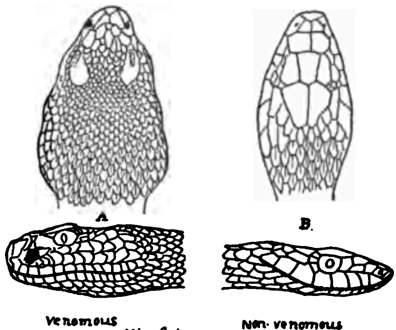

FIG. 21—THE RATTLELNAKE (A) AND THE GARTERSNAKE (B)

155. Snakes in captivity feed very little, indeed as a matter of fact, being cold-blooded and at the same time moving about very little, it is astonishing to see

how well they thrive on practically no nourishment at all for weeks at a time, and no anxiety need be felt that one is cruel in keeping a snake under observation for two weeks, even though he refuses to take any food whatever.

The Food of Snakes.

Turtles.

156. To those not accustomed to snakes, it would seem as if there was very little relationship between the turtle and the snake; but the truth is that they are not so distantly related as one might suspect. The scaliness of their legs shows their similarity in this respect to the body of the snake. The truth is both of them are descended from scaly creatures, of which the lizard is the nearest modern representative. The snake is a lizard which has grown long and lost his legs, though minute traces of them still remain in a few families. The turtle, on the contrary, has broadened his ribs and his breast-bone until they have formed, with some plates in his skin, a firm covering into which he can retreat in time of danger. The turtle pays for this safety, as his case makes him exceedingly heavy and consequently slow of motion. But the protection he enjoys makes him likely to live longer than any other creature with which we are acquainted. Turtles live quite comfortably in captivity and are very interesting. The land turtle eats freely most sorts of common vegetables, though turnips seem to be particularly relished. For water-turtles nothing seems quite so satisfactory as a small fish.

XII

THE BIRDS

157. WHATEVER may be the feeling of any teacher as to the desirability and interest of studying any other group of animals, there can be no difference of opinion in the matter of the birds. They are so unquestionably beautiful, they are so bright and cheerful, and their colors are so exquisite, their movements are so graceful, their behavior so varied and interesting that of all the animal world they certainly are the best subject for nature study. Besides it is most important that we should come to understand how intensely valuable the birds are to us. There seems to be no doubt in the minds of scientific students that were it not for the birds, a very large proportion of our vegetable life would be destroyed by the unending hordes of insects. Insects multiply so rapidly and are so destructive to vegetation that were it not for the kindly offices of the insectivorous birds, it is at least certain that our garden crops would hardly succeed. Long cultivation has made our domestic plants tender and they are no longer able to fight a fair battle against the wild plants of meadow and wood. Man himself, by his method of cultivation, can battle with the stronger plants, the weeds, that would enter into his field, but he stands nearly helpless before the hosts of insects. We are just beginning to realize what a bitter mistake it has been to deal so carelessly with our birds. With the disappearance of the birds from our garden, the increase in insect life is striking and ominous. Our bird students as

The Interest in Birds.

well as our insect students have begun to assure us in unmistakable language that if we wish to keep up the fertility of our fields, we must take care of our birds before it is too late.

The Feathers.

158. Every bird has feathers; no creature not a bird is possessed of them. There are two distinct types of feathers on a bird. One of these serves solely for warmth; the other, in its most distinctive type, is intended to beat the way through the air, or at least to shed the air when passing through it. To the first class belong the down feathers. These are usually close to the skin on the breast or the sides of the body underneath the wings. Each little branch that runs out from the main rib curls separately from its neighbor, making these feathers light and fluffy and forming for the bird the finest clothing known to the animal world. By this we mean that a covering of feathers protects the animal that carries it more thoroughly than any other form of clothing of the same weight. The birds need this clothing more than any other animals. Fish, snakes, and other cold-blooded animals have no need of warm clothing. It is only the mammals and the birds, with their warm blood, to which warmth in clothing is of any material advantage. This purpose is served by the feathers of the bird and by the hair of the mammal. The mammal carries a temperature not far from that of man, which is about 98 or 99 degrees Fahrenheit. Birds, on the contrary, range ten degrees higher, and the ordinary temperature of a bird would mean intense fever in a mammal. We find in some birds habits that subject them to great and sudden changes in temperature. On a warm summer afternoon a buzzard may descend within five minutes from an elevation where

The Temperature of Birds.

the temperature is probably not more than 40 degrees to where the temperature may easily be 90, while a few minutes will serve to return him to his previous altitude. To protect himself, with his high-heated blood, from such variation as this without serious chilling, requires clothing that must be very perfect indeed. If the buzzard were required to carry an amount of fur which would serve for this purpose, it would be so heavy that he could not possibly fly. It is to meet such emergencies as this that feathers serve better than any other form of clothing could.

Flight Feathers.

159. In the feathers used for flight, each side branch of the main rib has rows of hooks which reach forward and catch into corresponding ridges of the branch just in front of them, and this process is repeated for the entire length of the feather, making of such a feather a well-bound sheet which will strike the air without the parts separating from each other. If by any accident the feathers become ruffled, a very little preening on the part of the bird serves to bring them together again and to return them to their original condition. It is this sheet of light but firm webbing which makes an effective instrument for flight out of the feather of a bird. After feathers, undoubtedly the most striking possession of birds is the wing with its accompanying power of flight. It needs only the first glance for pupils to understand that the wings of a bird correspond to the arms of a man or the front legs of a dog. Backboned creatures either have four limbs or there is a story to account for their absence. These limbs may be modified for all sorts of purposes; occasionally, one or both pairs may be lost. Whales have lost the hind legs and turned the front pair into flippers; the snakes have lost both pairs; the fish have made fins of both pairs and

then have often lost the hind pair. Birds have, with very few exceptions, retained them both and converted the front pair into wings which usually serve them for purposes of flight, though ostriches have lost even this power.

The Shape of the Wing.

160. All bird wings are constructed on the same general plan. Ask the children to bring to school a wing of a chicken, from which the meat has been cleaned but in which the three bones still cling together. It is a profitable beginning in comparative anatomy to realize that the upper bone of the wing of a chicken corresponds to the upper bone of our arm and is hence called the humerus; the two bones of the middle joint correspond to the radius and ulna, while the third and last joint of the wing is made up of the consolidated bones of the wrist and the hand, the whole having become rather mitten-like, the thumb alone being free. The length of the wing varies considerably in different birds. In such birds as have uncommonly fine powers of flight, the wing is always long. The widespread pinions of the turkey-buzzard, who is the prince of fliers in our country, illustrate this most beautifully. But this length of wing is even more remarkable, considering the size of the bird, in the chimney-swift. Where the children have the opportunity to notice this active bird,—which, by the way, is often miscalled the swallow,—there will be no difficulty in noticing against the clear blue sky the long, slender, scythe-shaped wing that carries this bird in its wandering flight. Such a wing as this, however, must be kept constantly beating. The wider wing of the turkey-buzzard gives him his unrivalled power of sailing on outspread pinions with nothing but a waving motion, so slight as to be nearly imperceptible. Yet that slight

movement is sufficient to support him and to allow him to circle hour after hour through the clear air. It is a great pity that there is so much prejudice against the turkey-buzzard. He is by all odds our most skilful flier, and as for his habit of eating carrion, instead of despising him for it, we should be, and in the South they are, very grateful.

The Rounded Wing.

161. But when it comes to the short round wing, such for instance as is found in the chicken or in the grouse (commonly called a pheasant), such wing as this serves to carry the bird quickly forward, but after a short flight the bird returns to the earth. No wing of this shape can serve for long continued flight.

The Tail a Rudder.

162. There is quite as much variation in the tail of birds as there is in the wings. If the wings decide how rapidly the bird shall fly, it is the tail which determines the animal's power to dodge and turn, to quickly alter the direction of his flight. Such birds as the ducks, whose tails are almost lacking, have little power to suddenly alter the direction of their flight, and they must fly constantly in the open. Just the reverse of this state of affairs is seen in the splendid length of tail, with power to spread it like a fan, that we find in the great mass of little birds that live in the thickets. The bird which must spend its time flying about through the underbrush must be able to change the direction of its flight with entire promptness or it would be dashing itself constantly against the little twigs. It becomes very interesting to watch with care the insistent use of the tail by our catbirds and thrushes and all the little denizens of the thicket. Perhaps the most remarkable case of tail development amongst our native birds is found in our ruffed grouse, where the

tail can be spread if necessary until it stretches over nearly half a circle. It is this which gives to this splendid bird his power of rising instantly in the woods, to dart away with the speed of an arrow and never to strike any of the limbs which seem to lie in the direct path of his flight.

163. The legs of birds are quite as varied and interesting as their wings and for just the same reason. Each bird must be adapted to the work it has to do, and such adaptation is here secured by variation of the foot. It is natural for birds to have four toes,—that is to say, one of the five toes natural to the limb of a back-boned animal has completely disappeared from all of the birds. The one which has disappeared corresponds to the little toe of the human foot. Of the remaining four, three are usually very strong and well developed in the bird, but the fourth varies very much in the different groups, being nearly gone in the ducks and quite strong in the hawks. The foot of the chicken, with three well-developed toes in front and the fourth at the back, is well adapted to walking about on the ground and scratching in search of his food, which may consist of seeds or of grubs or of a large variety of objects which he may discover. The great majority of our small birds have three slender toes in front and one of about the same length in the back. This type of foot is chiefly valuable for grasping small twigs in the act of perching.

The Feet of Birds.

164. There has often been surprise expressed at the fact that birds can sleep without falling off the branch, but this matter is not difficult of explanation. Almost every child who lives in a home where chicken's feet have been severed from the leg when preparing the chicken for the table, has at some time or other picked

up such a chicken leg. He has noticed a string or tendon at the cut end and found that by pulling it the toes of the chicken could be made to close. This tendon runs over the joint in such a way that if the joint be simply bent, it tightens this tendon and makes the toes grip together. After the chicken has grasped the perch he lets his body rest down on the branch and this bends the leg as this joint, which is really the heel, so that it cannot let loose. If it wants to free itself from the branch, the chicken must stand up, and only then is there length of tendon sufficient to allow the toes to be unclasped. Another interesting form of foot in which the four toes are well developed is seen in the woodpeckers and a few other birds. These have the power of holding two toes in the front and two in the back so that their foot looks like the letter X. Such a foot as this has unusual power to cling to the erect trunk of a tree. Most birds take to the branches of the trees, but the woodpeckers cling with equal freedom to the erect trunk, a feat not to be imitated by any but a very few birds, most of which are not found in this country.

Sleeping on the Perch.

165. The hawks and owls show us still another type of bird-foot. Here again the four toes are well developed, and each provided with a long and sharp claw. In this case the muscles of the leg are strong enough to make of these talons, as we now call them, very effective weapons indeed. It is because these animals feed upon the flesh of other animals, which they capture alive, that they must be possessed of this savage power. The hawk can inflict on the human hand a most severe wound, and as for the field mouse or the rabbit, they are absolutely helpless in the grasp of these fierce birds.

The Grasping Foot.

166. It is a satisfaction to turn from these brutal weapons to the peaceful duck. Here the hind toe has nearly passed out of use, while the three front toes have had the skin which covers them extend out into a web which spreads between them to the end of the toes. This makes of the foot a very efficient paddle. While it is being turned forward

The Swimming Foot.

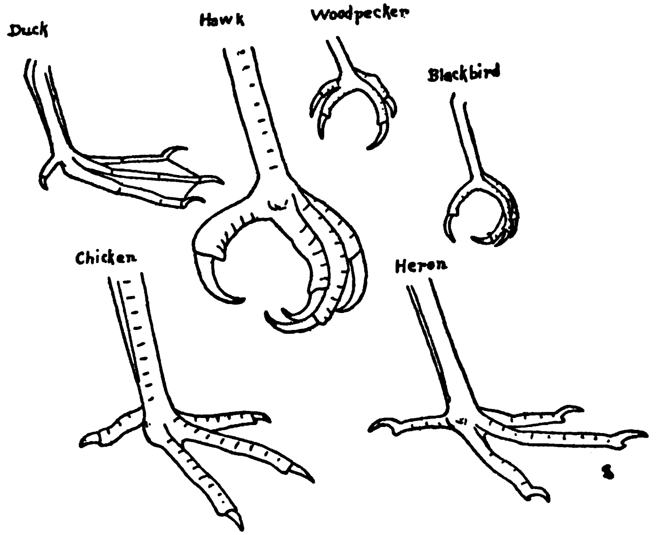

FIG. 22—THE FEET OF BIRDS

through the water, the foot is folded and the web swings loose, but when the foot is being rapidly pushed back through the water the toes extend to their full length and then catch a firm hold upon the water. The rapid stroke of the leg meets with great resistance from the water and sends the animal rapidly forward. The geese and the swans as well as the gulls and most of the sea-birds share this peculiarity with the ducks and such a foot comes to be known as a swimming foot.

167. One more form of foot shall claim our attention, that of the wader such as the heron or snipe. These creatures run lightly over the mud or wade in the shallow water of our streams. To fit them for this work, the legs have come to be greatly elongated. At the same time they are free from feathers, as these would be seriously objectionable if they were constantly wetted. By this means these birds are enabled to run about our streams and to wade in water even of considerable depth. In the case of the heron, this habit of hunting in the water is carried to the extreme. Sometimes for an hour at a time this bird will stand absolutely motionless, the frogs and the fish playing with great freedom about him. Suddenly one sees the flash of the bill and the head has been thrown down and some little creature has been captured to serve the heron for food. Of course every animal must be able to reach the ground on which he stands, with some organ that can convey food and water to his mouth. When a bird gets to have long legs, like a heron, this must be counterbalanced, either by a very long neck or a very long bill, or by a moderately long neck and bill. In the flamingo it is the neck whose length has been increased to match the legs; in the woodcock it is the bill which is unusually elongated; while in snipes and herons, as well as storks, both head and neck share in this duty.

The Wading Foot.

168. Another organ of the bird's body which varies considerably to meet the variation of habit, is the bill. Here specialization has not gone so far as in the feet, but there are several distinct types of bill. A bill for general purposes, serving for worms or fruits or insects, is seen in the robin. A distinctly specialized bill, shortened and hardened and thickened

Types of Bill.

so as to make it an effective instrument for cracking the shells of hard seeds, is found in our sparrows and their close allies. The little wood-warblers and nuthatches have a dainty little bill, slender and pointed, which serves for cleaning a tree of small insects.

169. In the birds of prey, like the hawks and the owls, the bill must serve to tear up what their claws have captured. In these birds, accordingly, the upper bill extends far beyond the lower, curving down in front of the lower bill and ending in a sharp point. The woodpecker has a most interesting modifi-

The Tearing Bill.

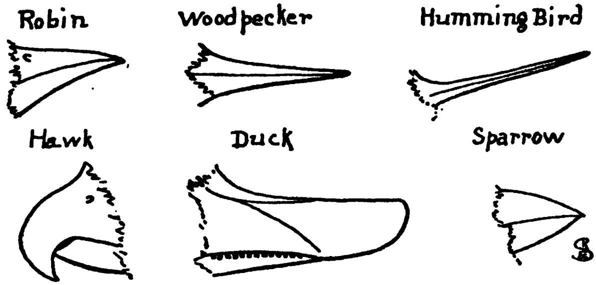

FIG. 23—THE BILLS OF BIRDS

cation of the bill. This serves as an effective instrument of laying bare the burrows of the larvæ of wood-eating beetles. When the bill has once punctured the burrow the tongue must do the rest, for the larva retreats along the burrow. But the woodpecker's tongue is long and slender, is sharp at the tip and is provided with barbs which point backwards and make it impossible for the animal which is impaled on the tongue to slip off. When the woodpecker has punctured his way into the burrow of the larva, he only needs insert his tongue in the hole thus made and push it, when it will follow the windings of the burrow,

The Drilling Bill.

impale the larva, and come out again with the larva clinging to its tip.

170. The duck has a highly specialized bill. This is a great broad shovel with which he can scoop up the mud at the bottom of a pond. Along the edge of both upper and lower jaw are projecting plates which, when the mouth is closed, lock into each other in such a way as to make a very effective strainer. By forcing the mud and water out between these plates, any solid material can be readily retained in the mouth, and, if it be valuable, be used as food. It will be noticed that the duck has a fleshy pad on the tip of his bill. This pad is most abundantly supplied with nerves of touch, enabling him to feel, down in the mud into which his bill has been inserted, the presence and perhaps even the qualities of any object with which his bill may come into contact.

The Straining Bill

171. Daintiest of all the bills is that of the humming-bird. This little creature has gradually changed from an insect-eater to a nectar-eater. He doubtless was led to this habit by the fact that his ancestors are true insect-eaters and upon the flowers they could easily find the sort of insect they relished. Doubtless while eating these insects they must have become accustomed to the taste of the nectar on which their prey had been feeding. Thus they acquired a taste for the nectar and their bills have developed into efficient instruments for collecting the fluid. The bill is long and slender and serves to penetrate to the depths of the flowers on which they feed and there to gather this fluid. The tongue, meanwhile, has become a tube through which the nectar can be sucked up into the mouth. But even these dainty creatures have not given up their old diet, and I have seen them industriously

The Probing Bill.

gathering up small insects from the bark of an oak tree.

172. No other habits of the birds are so interesting as those connected with their mating and nest-building, and with the care of their young. It is particularly desirable that the children should learn to watch the nesting habits of birds, because I am convinced that there is no other method so effective for preventing cruelty to birds as interesting children in their nesting habits. When the birds come to us in the springtime, their plumage is usually at its best. The males are brilliant in color and their song is brighter and more cheerful than at any other time. I am among those who believe this serves as an attraction to the mate. I can easily understand why many biogolists should hesitate to give to insects the power to choose a mate. But if there is such a thing as attractive coloration, it is to be found among the birds. According to this idea, the bird with the brightest feathers and the most attractive antics, or the sweetest songs, stands in the long run the best chance of winning for himself a mate. So it is that young birds owe their parentage to the brightest and most sweet-singing males. By this method brilliant coloration has been encouraged. The dull-colored birds in any one group are at least a little less likely to mate, and by this means, if the theory be true, the bird world is growing gradually more brilliant generation by generation.

Watching the Nest.

The Brilliant Males.

173. Of course the tendency would be for the females to grow brilliant as well, and it would seem as if in many cases where this is possible this tendency has produced considerable effect. The female oriole who sits deep in her nest is brilliantly colored, though not indeed so brightly as her more active companion and

mate. The woodpecker, whose home, hollowed out of the tree-trunk, completely conceals her, may safely flaunt a variegated coat. But most of the female birds in our temperate forests cannot afford to be conspicuous. They must sit for the most part in nests that are completely open. Under such circumstances to be conspicuous would be to notify their enemies and bring destruction to both mother and young. So it is that the brilliant tannager, with his splendid red body and black wings and tail, has for a wife a mate whose feathers are merely a dull olive. The same is true of the orchard oriole, whose nest is not so protective as that of his cousin, the Baltimore oriole. The orchard oriole is brown and black, while his mate has the olive so frequent in female birds. The red-winged blackbird, so common in our swamps, shows while flying a brilliant orange spot bordered with lemon, on either shoulder, and commonly sways in his flight, apparently to show these patches to better advantage. As for his mate, she is an exceedingly inconspicuous, striped and speckled female. In spite of this, he is constantly afraid when any one approaches the neighborhood of their nest and calls out in the greatest alarm as if to warn his mate.

The Dull-Colored Females.

174. That these brilliant colorations serve for the attraction of the female would seem further evidenced by the fact that by much the larger part of birds they are laid aside when the mating season is over. During the winter-time, many of the birds that we are accustomed to look upon as our most brilliant friends are exceedingly dull in color. One of the best examples of this change is found in the American goldfinch, perhaps better known as the wild canary. This dainty bird has a body of canary color,

The Bright Colors Attract the Mate.

with black wings and tail, and with white cross-bars on these black wings. It is with much surprise that one first learns to recognize these strange birds in the winter-time or indeed in the early spring. Then they look most uncommonly like the sparrows, to whom they are not distantly related. The bounding flight and the white cross-bars will serve to disclose to us, under this sombre garb, our dainty friend of the summer-time.

Ornamental Feathers.

175. There are certain peculiar feathers which are only carried by the male and often only in the mating season. The male of our black-crowned night heron carries, during this season, three long slender feathers, pure white in color, which branch from beneath his black crown and sway over his neck, reaching down to his back. Each of these feathers is curled and there seems to be no possible use for them if it be not to attract the females.

Pairing.

176. A very large proportion of our birds mate in pairs, the male and the female commonly remaining mated for the entire season, although the union rarely lasts longer than this. The next season, on returning, the birds seem to pair afresh. There are a few cases, particularly amongst pigeons and hawks, in which the mating seems to be of long duration, perhaps even for life, but this is not common.

Polygamy Amongst Birds.

177. In the case of our common chickens, as well as of the turkeys and peacocks, polygamy is the constant habit. One male gathers about him a half dozen or more females and guards them with jealous care from the approach of other males. This is a case of real polygamy, and if we are right as to the influences of mating habits on the coloration of birds, the effect of polygamy is very marked indeed. When one male gathers a group of a half-dozen of

females, this implies one of two things and perhaps both. He must probably be more attractive either in color or voice or manner than four or five other males with whom he is brought into rivalry for the female. It is necessary for him to drive off as many males as he wishes to have females in his group, because, on the average, there are as many males hatched from the egg as females, and unless they mate evenly such destruction of the males must occur. Our common rooster is gorgeously colored, is very showy in his movements, has a clear voice, and is ready to do battle with any rival who may appear in sight. The female, meanwhile, as is commonly the case with birds, is very much duller in color, has a far less attractive voice, and is distinctly quiet in her demeanor.

178. One of the most successful methods of attraction among the birds is that of the voice. Brilliant colors cannot be hidden and the bird which is bright enough to attract his mate is conspicuous enough to catch the eye of his enemy. Amongst surroundings which bring about joy on the part of the animal, the voice swells out; while should an enemy approach, it is an easy matter for the bird to keep silence. So it has come that the voice is perhaps a more frequent attraction, especially in the higher birds, than the plumage. Birds that belong to the lower orders rarely have good voices. It is almost only amongst the so-called perching birds that we find any remarkable power of song. The crowing of the cock can hardly be called pleasing except to the hen, although his very distant cousin, the bob-white, does have a melodious whistle. But as we get higher in the scale, and approach the thrushes and the finches, the voice begins to develop and the songs of some of our birds are the

Attractive Songs.

most musical of all the sounds of nature. So many people neglect entirely the songs of the birds, that I think few of us realize how much pleasure can be gotten from the knowledge of their notes.

Knowledge of Songs Desirable.

179. Most of us can tell a bird only when we see it, although we may be bird students of considerable experience. Then some day we will be thrown into the society of a bird lover who is distinctly ear-minded; that is, on whom impressions of sound have a very distinct effect and are well remembered. Such a person gives a name to every twitter as he goes through the thickets and woods, and many a bird that never would get into seeing range is recognized by his voice. The difficulty in this form of bird study lies in the fact that it is not easy to describe the song of a bird, though quite simple to describe his appearance. Hence our note-books are full of adjectives which describe rather our delight in the song than any real quality in the song itself. Even the cultivated student of music, who has power to write in musical notation the song which he hears, rarely seems to convey to his readers any very distinct impression of the song which he is attempting to describe. I believe, however, that the attempt to improve is worth making, and that practice will gradually enable us to describe bird songs so that they may be interpreted by others.

Writing Bird Songs.

180. Perhaps the commonest method, and for most people the most satisfactory, is that of making a bird say something. John Burroughs and Olive Thorn Miller have both of them done this very well, and almost every bird writer has done a little of it. The name of a bird is often an attempt to imitate its sound. No one who has ever heard the whip-

poor-will can even from the first have any doubt as to the identity of the bird. The phœbe's name is an attempt to imitate his love-note, while the chickadee says his name as plainly as any bird we have unless it be the bob-white. To make the oven bird say "teacher, teacher, teacher," or the Maryland yellow-throat say "witchery," is to give an idea to the reader that will certainly help him to identify these birds in the field. But whatever we put into these songs, the bird is probably simply giving expression to great joyousness, and joyousness which seems undoubtedly connected with the presence of the mate or at least of the mating season. There are a few birds whose songs the pupils can easily learn. The clear "bob-white" of the quail, the long-drawn-out "can't see me" of the meadow-lark, the warbled "cheerily" of the robin, the insistent "teacher" of the oven bird, are so clear and unmistakable that they can be very soon learned. A little later will come the less-easily described notes of the chippy, the bluebird, the brown thrasher, and the wren. After these common birds are recognized, the other songs will come gradually, and any effort spent in the learning of them will bring full reward of pleasure to the owner of the faculty.

Building the Nest.

181. When the singing and the maneuvering have had their reward, and the birds have begun to make their nests, a new seriousness comes over them. The song now is far less common, probably because the need for it is partly gone and because it would betray to the enemy the presence of the precious home. The nest is usually built in some out-of-the-way place, although it is astonishing to find how little it takes to hide these creatures. The low nest of the oven bird amongst the leaves at the base of some

tree in the forest, the meadow-lark's home concealed only under the grass of the meadow, would seem to be easily trampled upon; but it is astonishing, considering their abundance, how rarely they are found. Far safer apparently are the nests up in the trees; perhaps the safest of all, those in the trunks of the trees. When the woodpecker has hammered his circular way into the tree and expanded the hole into a great pear-shaped opening, perhaps eighteen inches deep, he has formed for himself as safe a refuge as bird can ever know. Well out of harm's way are those nests which are on the finer twigs toward the extremities of the branch, such as are built by the chippy or the king bird; while an additional touch of safety is added when the nest hangs beneath the limb, as does that of the red-eyed vireo and especially that of the oriole.

182. It is very interesting to watch the behavior of birds when in the nest. The food now gathered is often quite different from that used at other times of the year.

The Young Birds.

While the robin himself would prefer cherries, he will feed his young on tender bits of worm; and the flicker, who himself has a taste for beetle larvæ, will gather ants for the delight of his brood.

183. The habits of the young when they come from the nest are equally varied. Some birds have large-sized eggs. This means that the young may remain in

Eggs Big and Small.

the egg for a longer time and have more material from which to develop before coming into the world. The young chicken runs from the minute he puts his head out of the shell, as does the chick ostrich. A young killdeer will lie absolutely quiet on his ground nest, or the spot his mother calls a nest, for about one day and after that runs easily and

rapidly. At the other end of the scale the young robin comes blind and with no apparent habit but that of cuddling close to his brothers, and of opening wide his mouth as the father or mother gives the peculiar cry which means the approach of food. The robin's egg is small in proportion to the size of the robin, and it is for this reason that the young bird is so ill developed when it comes out of the shell. The chicken's egg is large, even in proportion to the size of the chicken, and it is this that gives the chicken its chance of development.

184. If anything is to be done to make the birds at home in the neighborhood of the school, get a little pan of water and put it up on a post out of the range of possible cats, and change the water each day. This will bring a great many birds within observation who come either to drink or to bathe. Food strewn about will coax many a bird, and Major Brown, the bird and bee man of the Middle West, says any one can have orioles who will scatter about the lawn, when apple-trees are in blossom, pieces of string about eighteen inches long. Bird-boxes do much to help, especially if they be kept nailed shut until the migrating birds begin to return and are only left open until these birds are gone. A lath nailed across a row of bird doors, when our common migrants are not with us, will save these houses from occupancy by the English sparrows, whose constant presence makes it easy for them to gobble up these choice places before the other birds appear. A piece of suet nailed to a tree some distance from the ground will have frequent visits from the woodpeckers during the winter season.

Attracting the Birds.

185. Few sides of nature study will have a more distinct value than work in favor of the active protec-

tion of the birds. To teachers who have a particular fondness in this direction, the Audubon Society will appear especially attractive. Membership in it is inexpensive and gives one the sense of helping on a good work. Its motto, "A bird in the bush is worth two in the hand," is a pleasant reversal of the old notion. The great work of this society is to foster a love for the bird world and to prevent the destruction of birds, either wantonly or for use as ornaments for hats. To those who care for feathers on their hats, the Audubon rule suggests that we wear no feathers except those of the ostrich, whose life is preserved for the sake of his feathers, or of our common domestic fowls, which are killed for the sake of their flesh and whose feathers consequently have not caused their destruction. If there is one feather which makes a good bird lover more sad to see than another it is the "aigrette," that is to say, the great plumes of the male white heron. The demand of fashion has nearly exterminated this bird, and when the society had a law passed protecting the egret, as this bird is called, and sent a man to be bird warden along the coast of Flordia where this bird breeds, this warden, an earnest and intelligent bird lover, was shot to death, presumably by the plume-hunters. It seems as if only ignorance of this fact could excuse one for wearing these feathers, for beautiful and attractive as they certainly are, it is beauty purchased too dearly.

Bird Protection.

XIII

DOMESTIC ANIMALS

186. WHEN we come to the fur-bearing animals, we somehow get to feel as if these were more nearly related to ourselves and as if the bond of sympathy between them and us was much stronger. We may succeed in taming members of other groups, a bird, a toad, but at best we never come to feel the same sense of companionship that hosts of people feel for the dog, the cat, or the cow. We may be mistaken in thinking that their minds work more like ours than do those of the bird or the reptile, and far more than do those of the insect or the crab. Many men draw the line, just below man and say that the mental activity of the lower animals amounts to almost nothing; that they have nothing that corresponds to man's thoughts; that their mental life is nearly a blank. I cannot come to this conclusion myself. While I realize that my dog has a decidedly restricted intelligence, it still seems to me there are the signs of at least glimmering thoughts. Certain it is that we take more kindly to the mammals, and they take more kindly to us than do other creatures. This group will divide itself for the purposes of this study into two distinct sections,—first, the domestic animals not necessarily or commonly present in the class-room but easily accessible out of class hours to every child; second, the wild creatures such as the squirrels and the chipmunks, ground-hogs and musk-rats whose presence is not so commonly noticed and whose acquaintance fewer of the children

We Understand Mammals Best.

have learned to make. It may be possible at times for a short time to have in captivity one of these latter animals. I say for a short time advisedly, because these creatures suffer so readily from neglect and appeal so distinctly to the sympathies of the children that they had far better not be in the school-room if their presence serves to render the children callous to the feelings of animals. Unless the animal can be kept in a fair-sized cage and under conditions that reasonably correspond to his wild life, he had better be let go free.

The Dog is the Best Subject.

187. Probably the best of the animals to study is the dog. He is far more of a favorite with the pupils than the cat and is altogether more amiable than the latter sly and egotistical animal. He submits readily to observation, at least at the hands of his friends and often at the hands of anybody who uses him with reasonable kindness. It seems to me stultifying to ask even the youngest child how many

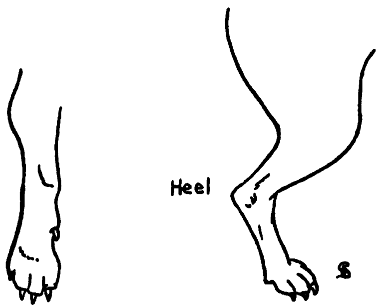

FIG. 24—THE LEGS OF THE DOG

legs a dog has, and such a question as that should never be used. But after you have passed beyond points as simple as this there is almost no question about the dog that cannot be made interesting, if reasonably handled. Perhaps the most suggestive of the ordinary questions

is to ask how many toes the dog has. The pupil will hardly be able to tell after he has looked, but a little questioning will bring out the fact that his dog probably has four useful toes on his front foot, while a fifth hangs limp and useless some distance up the leg; while on the hind foot, four good toes are found but commonly no fifth. This fifth toe on the front foot is called the dew-claw. It is the lingering evidence that the ancestors of the dog had five toes on each foot, the natural number for the back-boned animal in those days. When the dog's ancestor began to walk on his toes, instead of on his flat feet, the toe that corresponds to our thumb was lifted off the ground. The next step will be to locate the dog's shoulder; then his elbow and his wrist; and finally to see that he walks on his toes, while his wrist is up in the air. Still more startling will the change be when one looks at the hind leg and finds first the hip joint, then the knee close to the body, finally the heel, high above the ground, while only the toes rest upon the ground. It is when we teach a dog to sit up, as we call it, we practically teach him to stand on his heels.

His Disappearing Toes.

188. One of the most interesting points about the dog is his teeth. The teeth of fur-bearing animals are very well adapted to the nature of the food they eat. The dog is distinctly a meat-eater. His incisor teeth have chisel edges, but are very small. His canine teeth are so long that they cross each other and are used when he seizes his prey. The molar teeth of a dog are not grinders at all; instead of meeting each other with broad surfaces, as do the corresponding teeth of man or the horse, they glide over each other like the joints of a pair of scissors. This plan is most effective for cutting meat into fragments. The

His Meat-Eating Teeth.

truth is that the dog is a wolf, modified of course by long domestication and altered to suit his owner's whim. But the traces of the old wolf are still apparent to the practised observer, in both the form and the habits of the dog. The great canine teeth are the ancient weapons for pulling down his enemy. The ears of the wolf were distinctly erect and never hung over as do those of our dog. This is one of the degeneracies that accompanied the domestication and has undoubtedly been intensified by his owner. The dog, when taken into the home, no longer depends for his safety on the keenness of his hearing, and his ears, as do those of some other animals in captivity, begin to lop over. Man, pleased with the appearance, has cultivated the lop until we have the present ear.

189. But it is not only in the structure that the wolf sticks out of the dog, but in several of his habits. The constant custom which the dog has of curling before he lies down, is commonly attributed by the students of animals to a persisting habit. It was clearly brought out to me one day when I was out with my dog, and threw myself under the shade of a chestnut tree, along the edge of a field of growing oats. My dog, instead of throwing himself beside me, went into the patch of oats, and turned around two or three times, trampling down the oats in spiral fashion, and forming for himself a very comfortable bed, on which he proceeded to lie down. The motion was doubtless even in his wolf ancestors quite instinctive and the instinct remains, although the circumstances are very different. Give him a bunch of cushions on a couch, and a dog will soon trample for himself a comfortable nest, and even a single cushion has its power for forming a cosey resting-place distinctly enhanced by this

His Wolf Traits.

spiral tramping. But the dog doubtless has little intention in the matter. Before lying down, he turns around; if he is uncomfortable, when he is down, he gets up and turns again, doubtless quite as unintentionally as a nervous person clears his throat while speaking even though there is no obstruction in the passage of the voice.

190. Another trait that points to his wolf ancestry is the fact that he constantly barks at the approach of an enemy. This would seem really to defeat the purpose of the wolf, who wishes to catch the animal for food. But the wolf is a social animal and hunts in the pack, and so soon as he sees an animal which would be his legitimate prey or his well known enemy, his first impulse is to bark, not for the sake of warning his opponent, but because he wishes to summon the other members of the pack. I do not doubt that it is a part of the same impulse that makes the dog howl at night. It is usually on moonlight nights that this howling is most intensified, and this is naturally the sort of night on which the dog can most easily hunt. Accordingly when the moonlight comes the old impulse starts up in the dog, and sitting down on his haunches he lets forth the howl which is intended to gather the pack. The dog in the neighboring farmhouse hears the howl and responds, and all around the country side the dogs answer the ancient call. But domestication has taken the meaning out of the impulse, and the animal contents himself with howling and practically rarely attempts to join the other members of the group. One habit of the dog is to me intensely interesting. It is his constant desire to keep the tip of his nose moist and clean so that he may smell keenly.

Barking at His Enemy.

191. It seems to me that the origin of the dog in the

wolf tells the story as to why he is so easily domesticated. The wolf is a social animal. He is accustomed to live in packs and in this pack the majority of the animals are accustomed to give entire obedience and submission to the leader. This begets in the animal a train of instincts which fit him unusually well for domestication. He needs only to transfer to his master the obedience which his ancestor owed to the head of the pack. It is an interesting thing that most animals which man has succeeded in domesticating are such as in the wild state go in packs. This has made them much easier of domestication. The apparent exception is the cat. But she is to-day but very indifferently domesticated.

The Origin of His Sociability.

192. The dog is a social animal; he hunts in packs and acknowledges a leader. The cat is a solitary creature; she hunts alone, as did her ancestors before her, and she acknowledges no leader, will serve no master. From this results the fact that the cat is distinctly unsocial. At least nine cats out of ten prefer a warm pillow, to which they are accustomed, to a person. The dog through his whole life is devoted to his master, whom he will follow everywhere. Whereas the dog barks at his prey, the cat tries to creep upon her prey as quietly as possible. The dog summons assistance, the cat seeks prey she can handle alone. When the dog runs along a pavement or floor, you can hear his nails rattle when they strike the surface on which he is travelling, but in the cat, elastic ligaments pull her claws far up into her feet. So soon as she wishes to use them, muscles on the under side of the claws pull them down and they protrude so as to form savage weapons with which she holds fast to her prey. With claws drawn into her toes, with

The Unsociable Cat.

feet covered with soft pads, with movement that is absolutely noiseless, a cat creeps slowly toward her prey or watches quietly and patiently near where she knows it must pass. With a sudden bound, and with all her claws turned out, she leaps upon her victim, striking and holding it far more with the claws than with the teeth. The canine teeth, however, are long and lap over each other, and the jaw is very short. When the cat sets her teeth into her victim, she usually holds on, and does not snap as most dogs do.

193. The cat's method of hunting, depending upon concealment, is much better adapted to night than to day, and so the cat is essentially a night prowler. In the daytime she is a dull and sleepy creature and so we are apt to think of her. But if she is granted a reasonable freedom, the night is the time in which she really lives. Now she prowls about the thicket, beneath the bushes, watching for the sudden run of the field-mouse, and woe be to the nestling bird that has been too venturesome and has dropped from the nest before he can fly. Such birds almost always fall a victim to the cat or her prowling allies.

Her Still Hunt.

194. It is interesting to note the play of young animals, and perhaps no animals are more interesting in their play than kittens. Their intense activity, their fancy for any rolling objects, and the quickness with which they pounce upon a moving handkerchief, are delightful. Play has two distinct functions, whether in animal or in man. The first is to give an outlet for the excessive energy of a growing animal. It is such play as this that we see in the horse, when he turns on his back and rolls. But much the more important function of play is to prepare for the activities of life. It is this that

The Meaning of Her Play.

gives zest to athletic games; it is this that makes the girl play with dolls and keep house, and it is this that makes the kitten leap at a ball or at a handkerchief drawn in front of it. Of course she is not intentionally preparing for life, but none the less the instincts which arise in her serve exactly that purpose. The cat is an animal of questionable standing in modern society. In most things she is altogether irreproachable and her propensity for gathering mice is from our standpoint quite praiseworthy. But she will insist on eating young birds, being quite as fond of them as we are of broilers, and she kills off our song-birds at a rate which has made many a bird lover her emphatic enemy. The Audubon Society suggests that you check the increase of your kittens and that cats never be allowed to stray while the owners are away from home.

Her Sensitive Whiskers.

195. Not the least interesting feature about the cat is her set of whiskers. It needs but little observation to show that these are far better developed than are those of the dog. The dog rather dislikes having his whiskers toyed with, but the cat finds this a serious annoyance, and except at the hands of very intimate friends will not submit to it. The dog's whiskers are straggling and irregularly bent. The cat's whiskers are beautifully curved and stand out with regularity. These long stiff hairs are entirely different from those that cover the body and serve a different purpose. At the base of each hair is a nerve of touch, and when anything comes in contact with the outer end of the hair the motion is promptly transmitted to the nerve at the base and news of it brought to the brain. The cat's whiskers reach far out from her mouth and the result is most interesting. It is not an uncommon sight to find a dog stuck under the

fence; he has attempted to creep through a hole too small for his body. One rarely finds a cat in such a situation. Should she think of entering a hole she needs but put her head into the opening when her long whiskers serve her as an accurate gauge of the capacity of the hole. By this measure she can tell definitely whether the hole is big enough to accommodate her body. When the whiskers tell her the hole is too small the cat, unless absolutely distracted by fright, will not think of attempting to pass.

The Horse an Early Friend.

196. One of the domestic animals that has for a very long time lived with man is the horse. At first man ate him, as we know from the pictures which the cave-man drew on bone or on the walls of his cave. It was probably much later that some tribe learned to use him as a beast of burden. We have noticed the fact that the dog in rising on his toes, has elevated one toe off the ground. The horse has carried this much farther; his forefathers have elevated and lost toe after toe. His earliest ancestor with which we are acquainted was about as big as a fox; but as his descendants grew taller and longer of limb, they dropped toe after toe, until now our present horse runs on the middle toe of each foot and shows no external sign of having had more. When we come to examine his bones, however, it is easy to notice the remains of two more toes, though they no longer project through the skin. As the horse has taken to walking on one toe, he at the same time passed from a lowland to an upland animal. On the new and harder ground his nail developed about his one toe until it has grown into the present hoof. On his native plain, this wears away as rapidly as it grows, but when we put him upon our hard roads, the nail

His Single Toe.

would be altogether too soft, so we tip it with iron. This entirely prevents its wearing away and the nail would grow too long, did we not pare it for him every time we change his shoes.

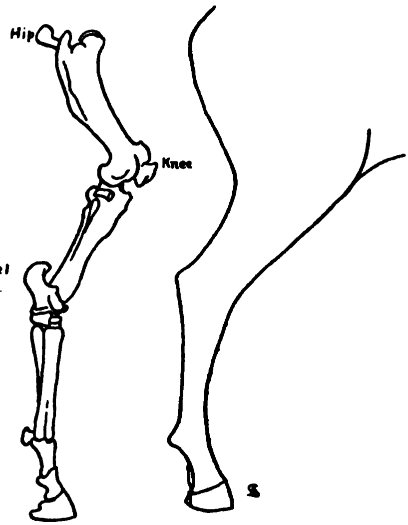

FIG. 25—THE HORSE'S HIND LEG

197. As the horse slowly raised his body from the ground on his lengthening legs, in order that he might reach the ground with his mouth, his neck and particularly his head have lengthened. So it has come to pass that the horse has acquired an unusually long head, much of the length coming between the canine and premolar teeth.

His Lengthened Head and Neck.

198. The cow, take it all in all, is doubtless the most useful of all the domestic animals. She is often raised simply for the fact that we can eat her; but in closely settled countries it is her milk-giving qualities that have

endeared her to us. Most of us quickly forget for what the milk is intended, or even complacently consider that she was intended to give us milk. Of course the milk is meant for her calf, and she never produces milk until she has had a calf. When we take the young from most animals, the milk promptly dries up, and in the case of ill-bred cows such is likely also to be the case. I am told by one who was for years a resident of Egypt, that the small poorly-bred cows of that country promptly cease giving their milk when the calf is taken away, unless the owner takes the skin from the calf, stuffs it with straw, and stands it upon four sticks for legs. When this is placed beside the poor deluded mother she caresses it, licking it lovingly, and keeps on giving her milk. In the better bred stock of this country, we have through long generations accustomed the cow to keep on giving her milk long after we have taken away the calf.

The Cow is the Most Useful Animal to Man.

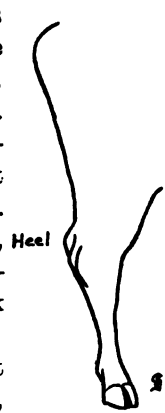

FIG. 26—COW'S HIND LEG

199. Like the hind feet of a dog, the feet of a cow have completely lost one toe, but of the four remaining toes two are used for walking and are firm and hard. These make the "cloven hoof." The other two toes still hang behind the cow's leg as small and useless remnants. Such a foot as this is not so well adapted to hard soil as is the single hoof of the horse, and the cow, not being so well able to escape from her enemies as is the horse, is somewhat better provided with means of defence in the shape of the horns which grow out of her forehead.

Her "Cloven" Hoof.

200. Perhaps the most interesting feature of the cow, a feature which she shares with the sheep, the goat and the deer, is her peculiar method of eating.

The Ruminating Habit. The cow has completely lost her incisor and canine teeth in her upper jaw. Instead of them, she has across the whole front of her mouth a crackled pad, much like that on the foot of a dog. Her lower front teeth do not strike fair against this as our teeth meet each other. Instead, the lower teeth slip forward, pressing their upper sides rather than their tips against the pad. These lower teeth are movable, as if set in rubber. The tongue is very long and flexible. With it the cow catches up a bunch of grass, draws it across her lower teeth, pinches it between them and the opposed pad, and throwing her head upwards, cuts off the grass with the lower teeth. The horse, by the way, would catch the grass between his lips instead of with his tongue and pull his head toward him instead of upward. The horse, too, would stop to chew the grass; the cow does not. She swallows it whole and can keep on nipping and swallowing grass for an hour. Then if there be a tree near by, she will lie down beneath it and the chewing process begins.

201. When the coarse grass was first swallowed, before it had reached the true stomach, it pressed open a slit in the under side of the gullet and slipped down

Chewing the Cud. into a big bag called a paunch, and here a large amount of food collects. Opening out of this paunch is another pocket called the honey-comb, because ridges shaped like the honey-comb stick out of its walls. In this pocket the grass is rolled up into balls about the size of small apples. When the cow lies down beneath the trees, she is able to force up one of the balls of grass, which we call a cud. The cud passes through

the slit and up the gullet into the cow's mouth. Here she slowly and carefully chews it, this time swallowing it. In this fine and moist form, the food passes over the slit of the paunch and on into a strainer called the many-plies, because its surface is folded like a closed fan. After the chewed grass is well strained here, it passes on into the true digestive stomach.

202. The fact that the cow was originally a wild animal, with little means of self defence, is doubtless the explanation of its strong chewing power. This allows the animal to go out into the open, gather what food it quickly can, and retire into the obscurity of the thicket, where at its leisure it can chew and digest the food it has thus hastily gathered. These animals are keen of smell and it is interesting to notice that whenever the wind is at all brisk the cows in the field are likely to face toward the wind as they feed. It is a remnant of the old instinct which taught them to watch for their enemies in the direction in which they could catch them farthest away.

The Origin of the Cud Habit.

XIV

WILD ANIMALS

The Success of the Rodents.

203. Most of the wild animals of our woods have disappeared before the approach of man. Almost all those which have succeeded in outwitting him, and have kept up their numbers, are small and inoffensive creatures which owe their safety to their timidity and quickness. They chiefly belong to one great family, known as the gnawers or rodents. Their peculiarity is the fact that they have only two front teeth in the upper jaw and two in the lower jaw; they have no canine teeth and there is a long gap, as in the horse, between the front teeth and the back. There is an interesting peculiarity about these front teeth. Whereas in most teeth the ivory or dentine is on the inside and the enamel on the outside, in these, the ivory is at the back and the enamel at the front. The ivory is much softer and wears away faster than enamel, and this process keeps a sharp cutting-edge of enamel on the front of the tooth. The whole tooth keeps growing continually and hence can be worn hard without being rubbed to a stump. In this group

Fig. 27—The Teeth of the Muskrat

of the rodents we have, amongst others, the rats and the mice, the squirrels and the chipmunks, the musk-rat and the beaver.

204. I have never watched any other animal in captivity that kept himself so scrupulously clean as did a gray rat. I had often wondered what was the purpose of the long, slender, nearly hairless tail of the rat and the mouse, but I think this fellow taught me the truth connected with it. The short, stiff hairs of this tail have nerves near their base, and hence serve for the sense of touch. The rats and the mice live constantly in long and narrow burrows and it must doubtless often be necessary for them to retreat rapidly in a hole so small that they cannot turn around in it and it must add largely to their ability to run backwards through the hole to have a sensitive organ which can precede them.

The Interest of the Rat.

205. The squirrels are members of this group that have taken to living in the trees, and here once more the tail has received a peculiar development. It has long hairs that spread out in two directions, forming a thin parachute. This undoubtedly makes it easier for these creatures to make their long leaps through the air. It doubtless supports them somewhat but probably is more effective as a rudder, giving them a power to light on the spot at which they aim. Of all the rodents they seem to be the safest from harm and consequently to live most comfortably close to man. But they pay for it by a life of constant alertness, for I know of nothing else so nervous and quick in its movements as a squirrel. Once they have learned that man is their friend (and they are quick to learn it) they become quite fearless. In the Pennsylvania capitol grounds at Harrisburg I had four squirrels

Squirrels and the Tree Habit.

clambering over me at one time. One was on my knee, one on my arm, one on my shoulder, and one on my hat. They had never seen me before, but in less than half an hour, with chestnuts and almonds, I succeeded in gaining their confidence.

206. The little striped-backed chipmunk is not social like the squirrels, but with a little encouragement he, too, will make friends. Instead of living in the trees, the chipmunk makes a burrow for himself under ground and this he fills with wheat or cherry-stones or chestnuts, often in quantities one would think enough to last for several winters. He is particularly adapted to gathering such food. Inside of his mouth in each cheek he has a fur-lined pocket and this pocket he can stuff with the material he wishes to carry home, until his head is flattened like that of a snake. One summer while living in the woods a chipmunk near my cottage became more and more friendly each day. Soon we learned to put a plate on the veranda for chippie, and on the plate we put all the cherry-stones that accumulated at the table and not a few of the kernels of almonds and English walnuts. The chippie grew quite at home and would take a nut kernel from the hand of almost any member of the party who would sit quietly while feeding him. My daughter seemed to be unusually successful in making friends with the chippie. She placed a nut kernel carefully in each hand and closed her hand upon it. The chipmunk ran up into her lap, forced his nose into her closed hand, took out the kernel, stuffed it into his cheek, ran over to the other hand, gathered that kernel also, and then away to his nest. One morning I carefully counted the cherry-seeds as he stored them away and one chipmunk carried in his two pockets, at

The Unsocial Chipmunk.

one time, thirty-nine cherry-stones. There may have been some outside of the pockets in the mouth, but his mouth was closed on them and his head looked preposterously wide.

207. The ground-hog is a distant cousin of the squirrel and of the chipmunk. He burrows in the ground, but he does not stow away food in any quantity in his burrow. He is stupidly fearless and even at the attack of a dog will often stand his ground. When he runs, his gait is awkward and not very rapid. Altogether he is much lower than the other members of the group. The ground-hog feeds on most of our common vegetables, with perhaps a special fondness for apples and turnips. His habit of sleeping over winter is well known.

The Stupid Ground-Hog.

208. Our common cotton-tail is a great favorite amongst the country boys, though I fear the chief fondness for it is as a mark to throw at and as a variety in the fall food. The rabbit ordinarily eats green food and is partial to the tender vegetables of our gardens. When winter overtakes him, however, he is very apt to be driven to eat the young bark from sapling trees. It is this habit that makes him so severely disliked by nurserymen. The white tail of the rabbit has received an exceedingly interesting explanation. It is one of the cases of recognition marks. In case of sudden danger the rabbit can run quickly, and her young have an unerring guide to follow in the quivering tail with its white tuft.

The Rabbit's White Tail.

209. We have always regretted the disappearance of the beaver with his habit of building dams and houses in the water; but the truth of the matter is, that our common musk-rat is in many respects as interesting as the beaver and very much like him except in size.

While he will not build much of a dam, he will build houses in the dam if you will furnish the latter. In the banks of a running stream he will build a burrow with its opening beneath the surface of the water, and to this he will bring large fleshy roots of all kinds. In front of it you will frequently find great quantities of the shells of the mussel. Whenever he can find a dam instead of a running stream, he builds himself a house of sticks or corn-stalks and of mud. He makes the entrance to his house beneath the water and the whole looks so like a mass of drift-wood as to commonly attract little attention.

The Musk-Rat is Like the Beaver.

210. The varying habits of passing the winter among the members of this group is most interesting. The rat, the mouse and the rabbit hunt their food in winter as well as in summer. When food is abundant, they have plenty; when it is scarce, they starve. The musk-rat and the squirrel store a considerable amount of food, but any pleasant day during winter they will frequently forage for additional material. The chipmunk puts away enough food to last him all winter and does not show his nose above the ground until the weather is pleasant; meanwhile he lives comfortably and cosily in a warm burrow, with lots to eat. The ground hog takes a simpler method. He crams himself with food whenever he gets a chance, and by the time fall comes he is fairly loaded with fat. He disappears into his burrow and goes into a stupid sleep. At his slow rate of living, his fat is enough to keep him for the winter, and he stays there until spring, when a bright warm day will bring him

How Mammals Pass the Winter.

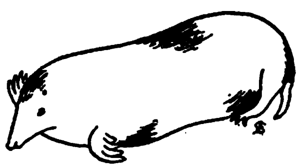

FIG 28—THE MOLE

out. The curious notion that the second of February is his day to try the weather, and that he can prophesy the condition of the weather for the next six weeks, is of course nonsense.

211. The propensity which the mole has for digging in the lawn, raising a ridge in the sod at the same time, and the fact that he apparently loves freshly-planted beans and peas, makes him an object of dislike to the farmer. Accordingly the mole is apt to be killed as soon as he is seen. But if we can stay the hand long enough for the school to get a good study of him, he will perhaps pay for his misconduct. If the boys can be persuaded to return him to the woods, instead of the fields, he may be permitted to live without disadvantage to us and doubtless with great addition to his own pleasure. The soft fur of the mole is one of his daintiest characters. He can come out of the ground and give himself a whirling shake and be free from every sign of the earth through which he has taken his way. It is almost impossible to believe that an animal can live in dirt without being dirty, but the mole certainly does. His fur is softer and finer than that of any other of our mammals. His life under ground gives him so little use for his eyes that, from the outside, little more can be made out than a dent in the fur, out of which it is very doubtful whether the mole sees much of anything.

The Digging Mole.

212. The most interesting adjustment of the mole's body to his digging life is seen in his big front paws. These are short and stout and end in strong claws. Flexibility of the hand is practically gone and when he walks he rests on the edge of his hands instead of on the flat palms. This gives him a very awkward gait, but once let him get

His Shovel Feet.

beneath the surface and it is astonishing to find how rapidly he can make his way through the earth. When the mole is taken into captivity, he will eat apple, although his native food is believed to be earth-worms and small insects. He is very fond of water, which he takes greedily, and he must not be allowed to lack for water or he dies quickly.

The Misunderstood Bat.

213. When one overcomes his antipathy to the bat, the creature is exceedingly interesting. One need not hesitate to pick it up; its teeth are so small that its bite is almost ludicrous, and it is easy to catch one wing in each hand in such a way that the animal cannot bite. It is the wing, of course, that makes this animal interesting. In the bat's wing the thumb becomes a short claw, while the rest of the fingers are enormously long. The skin stretches between these fingers and along both sides of the arm and down the body to the hind leg. This wing has somewhat the feel of thin rubber, or of a sort of silk, and is exceedingly beautiful. On looking through it toward the light, its blood-vessels will be seen to divide and subdivide until they make a complete network. This little creature flies about in the evening, capturing insects.

Structure and Habit Fit.

214. In the study of animals and plants, as rapidly as the child's mind is ready for it, there should come reasons for structure. This is an exceedingly interesting form of study. A natural mind hungers to know why things are as they are. While it is true that a very great many of our explanations of things will prove to be valueless, and occasionally prove to be altogether wrong, this is no reason why, until we have better information, we should not use our present explanations. A habit of looking for

reasons will arise which is far more valuable than any actual information that may be gained at any one point. Only we must take care not to be too dogmatic in the matter of our explanations. Our pupils will soon learn, provided we are modest enough in our statements, that these conclusions of ours are liable to be mistaken and will be corrected when we know better. We will be slow at learning better unless we keep on training young people into a desire to know why things are as they are.

Our Frequent Mistakes.

215. The scientist occasionally looks aghast at the work in nature study and laughs at its blunders, as if science herself made no blunders. It seems strange that men who are accustomed to find advanced text-books on their own subject useless after ten years, should quarrel with the nature student because of the absurdity of some of the things he does. The nature teacher must try his best to be right and then go ahead, never hesitating to correct himself so soon as he knows better, but not deterred by a too blighting fear that what now seems to him to be true may some time prove to be wrong. Probably one-third of the statements in any scientific text-book which is at all near to the front of investigation will be found in time to be wrong, or at least extremely partial, but for the present that book represents the best we know and for that reason is the nearest approach to the best we shall know a little later.

216. There is a school of psychologists investigating the mental life of animals from the lowest organisms up to the highest. Some of these men are for the present finding animals strangely mechanical, though now and then there are found traces of individuality far lower down in the scale than we would expect. The

present swing of the pendulum is to give animals a very mechanical mental life. This is a reaction from a previous tendency to make animals almost as intelligent as man. The pendulum swings back again from side to side, and it will be long before we have any certainty in the matter. My personal feeling is that we will find the higher mammals less mechanical than it is the present fashion of science to believe, and we will find that man is more mechanical in the great mass of his mental activities than we had realized.

The Psychology of Animals.

217. But this is altogether a different problem from the one the nature teacher has to confront. He must face his own problem and realize that he is to teach the child-mind. I am quite confident that when he personifies the flowers and fruits and makes animals do things with the intention of securing that which they really do secure, he will not be misled as much as the scientist is tempted to think. The impression it makes on the minds of the pupils at their time of life is nearer the truth, and in the course of time will grow into the truth better than if, in their imaginative minds, we should paint the facts in the sombre colors and the hesitating outlines of one whose scientific conscience forbids his asserting clearly that which is yet in doubt. The only way in which a child can understand an animal is to make that animal act from at least some of the simpler motives with which he would act; otherwise the actions are meaningless. Primitive man explains things thus, and the child is primitive man. It should be our care to so present these primitive notions, that there shall be in them the power to grow, as the child grows older, into the concepts of modern science. We must not let the scientist

Personifying Animals.

frighten us unduly. When he has settled the problem of the mind of animals to the general satisfaction of his fellow scientists, the young teacher will not be far behind in catching so much of the spirit of his investigation as is suited to the purposes of elementary instruction.

XV

THE GENERAL LIFE OF THE PLANT

218. A SEED is a plant baby with a legacy large enough to support it until it is able to work for itself. Somewhere about the new plantlet, the parent plant has stored enough of starch or of oil, or some such other inheritance, for the baby to feed upon. The plantlet in the seed has the essential parts of a full-grown plant; at one end is the beginning of the root, at the other the very first leaves, and between them the stem. These parts can be readily made out in the bean or pea where the two seed-leaves make up nearly the whole of the seed, while the stem with its root at one end curls along one side. In the walnut or hickory we have the two leaves plainly standing apart and between them, at one end, a cross-bar with two points. In this cross-bar is the stem and from the point nearest the end will spring the root. From the opposite point, lying more clearly between the halves of the kernel, will come the new shoot.

The Meaning of the Seed.

219. It is this rich store of nourishment, packed away closely, that tempts so many of the animals to eat seeds. Man has cultivated the grains and the nuts. Many birds, like the sparrows and the canaries, have short, stout bills for crushing them, and many insects, particularly of the weevil kind, make them their homes.

Using the Nourishment.

220. The plant was actuated by no consideration for us when it packed away all the food. The seed finds itself on or in the ground. With the opening spring,

Seedling and Flowering Mulleins

when the proper amount of moisture and warmth has reached it, the lower end of this plantlet stretches out into a root, covered with its delicate plush-like root-hairs. This pushes on, guided by impulses that cause it to grow downward, away from the light and toward water. When the root is well out and fastened, the stem erects itself and throws its tip-bud up into the air. As the plant grows the part containing the stored nourishment becomes steadily smaller and finally dwindles away.

The Plant's Use of the Nourishment.

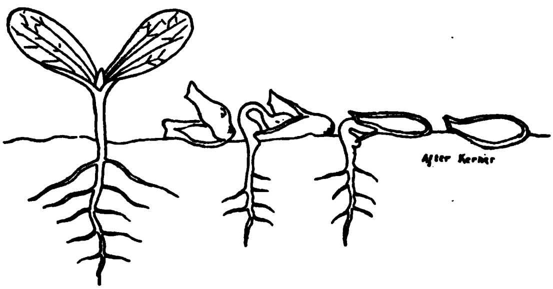

FIG. 29—GROWING PUMPKIN SEEDS

221. Such a seedling plant is already furnished with all the primary organs of the plant which, for the purposes of our study, may be looked upon as root, stem and leaf, though the last two are sometimes spoken of by botanists as one and the parts are then known as root and shoot. Each of these members has a very definite work to do.

The Parts of a Plant.

222. The root of a plant has regularly two duties to perform. First of all, it must penetrate the ground in all directions and gather for the plant its moisture and its dissolved mineral matter. Roots cannot stretch, as young stems do, or they would shear off their side branches. They can only grow by addition to their

ends, boring their way through the earth. But here another difficulty presents itself. The growing tip of the root is necessarily tender and would be readily injured as it insinuates itself into the crevices of the soil. Accordingly it is provided with a thimble-like root-cap. This cap has its growing surface on the inside next the growing root-tip, and as the outer, dead portion wears away its place is taken by the later-formed material.

The Work of the Root.

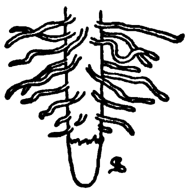

FIG. 30—THE GROWING ROOT-TIP

223. As has been previously mentioned, in almost all plants, the roots tend strongly downward rather than upward; away from, rather than toward, the light; and toward, rather than away from water. As the root-tip elongates and branches, each tip goes through a slow spiral movement. It is this feeling about that allows the roots to find each cranny and crevice in the soil and to enter in search of water and the mineral substances dissolved in the water. Just back of the growing tip the root is covered with a fine plush-like coating. Into this plush the water soaks, as it does into a prune when it is allowed to lie in water, and the material this absorbs is handed on through the stem to the leaves of the plant.

The Growth of the Root.

224. The root's first duty of gathering nourishment having been performed, another function usually follows, namely, that of holding the stem rigidly in place so that it may lift the leaves into the air and sunlight. Some roots fail in this work, usually because the stem is too weak to make it worth while, and then the plant either lies prone on the earth or clambers lazily to the light by clinging in some way to a sturdier plant.

Holding up the Plant.

225. Whenever a plant has a life longer than one year, the roots are very apt to have thrust upon them

FIG. 31—JACK-IN-THE-PULPIT

at least a share of a new duty, that of holding stored nourishment over winter. Sometimes, as in the beet and turnip, the root does this alone; sometimes, as in most of our trees, a large part of the winter store lies hidden also in trunk and

The Root as a Storehouse.

branches. Such store of rich material, usually starch, is naturally a strong temptation to predaceous animals, whether boy or must-rat, and accordingly many plants have learned to protect themselves. In the case of the well-known "Indian turnip," which is, strictly speaking, the underground stem, rather than the root, of Jack-in-the-Pulpit, the material is intensely biting to the tongue. Other roots give themselves so unpleasant a taste as to escape molestation. The horse-radish and the blood-root are well-known examples of this tendency. Man, with a peculiar perversity in such matters, has dug up the pungent horse-radish. He grates it and puts a very little of it on his food to give it what he calls a relish. I think mustard and spice generally are similar cases in which a material which originally served as a defence to the plant is used by man, in very small doses, because he likes to be poisoned just a little. The tobacco leaves, laden with nicotine for their own safety, are now relished by two creatures, man and a long, green caterpillar.

The Light-seeking Stem.

226. The stem is the aspiring part of the plant. Its prime work is to produce from its growing tip, successively, the new leaves and, later, branches bearing leaves, and to lift them up into the air and the sunlight. Plants need never choke each other in their battles for air, because air can travel in and out and bend and twist until it has reached the last little corner. But light travels in straight lines and most of the variations in height and position of grass, herb, shrub and tree are but adaptations on the part of the plant to secure its share of the precious energy, streaming down from the sun, and only to be made available for the purpose of life after it has been acted upon in the green leaf. So the great function of the stem

is to put each leaf where it can catch its share of sunshine. The stem is also the great highway for interchange of products between root and leaf.

227. If plants are to live only for the warm portions of a single year, the stem is usually tender, like the leaves. There is scattered through it much of the pulp, and this contains the living material of the plant. This pulpy material is built up of exceedingly small sacks of the life-substance, which the scientist calls protoplasm. This is the only really living material substance on the earth. Plants are alive and animals, too, solely because they are made of these so-called cells of protoplasm. In the tender young herbs, that live for but the one growing season, much of the stem is made of this pulpy substance. The strands of stiffening and the sap-carrying pipes make up but a small part of it. The proportion of stiffening to pulp in tender plants is readily seen if we tear a stem of celery and notice the curling strings that pull out, or stand a stem of Touch-me-not in water colored with red ink. Then the strands of stiffening fibres and conducting vessels immediately become evident. Such a stem as this depends for its stiffness on its being kept absolutely saturated with water until every cell is as plump as a prune that has been soaked over night. Let evaporation from the leaf surface go faster than the roots can supply new moisture, or tear the plant away from its roots, and the stem rapidly becomes limp and flat,—that is, it wilts. Let a heavy frost appear and each cell is ruptured, and even perhaps its protoplasm frozen and killed. Such tender plants are known by the fine old Saxon name of herbs.

The Living Pulp.

228. While it is true that a very large number of plants live but a single year, there are others which,

while not attaining to the dignity of a long life, still last two or three or more years. This time is too short, apparently, to make it worth while to put out a woody stem that is hardy enough to outlive the winter. Accordingly during the first year

Underground Stems.

FIG. 32—SOLOMON'S SEAL

the plant gives itself up entirely to leafing. All the rich growing material it produces and does not immediately need, it carries down below the ground. Here

it is gathered in a fleshy, well-stored root or in an underground stem. In plants which last two years, in their native habit of growing, such as the beet, radish, and turnip, the nourishment is commonly stored in roots. The Solomon's Seal, the May apple and such plants last longer; the parts above ground dying down each year, and the new growth the following year coming out a little farther on. In this way, the underground stem gets a knotty, jointed structure, which distinguishes it from a root. But it is in the plants whose lifetime is prolonged for a series of years, varying from only a few years in some of the shrubs to perhaps two thousand in the greatest of trees, that the most careful provision must be made. In this case the stems have mingled with the pipes that carry the sap a very large proportion of thickening walls and stiffening fibres, and this constitutes the bulk of what is commonly known as wood.

229. All growth in thickness of the stem is produced by the cambium or thin line of tissue lying just between the bark and the wood. In early spring this cambium layer is rapidly forming the larger pipes to serve for carrying sap. This makes possible the common practice amongst children of choosing a coarse-grained wood that has at the same time a fairly tough bark, like the willow or chestnut or maple, for making whistles. This is chiefly a spring practice; for after the fibres of wood begin to be thoroughly hard there is much more difficulty in slipping off the bark without splitting it. The tube between nodes,—that is, between budding points,—is wetted to soften the bark fibres so it will not split. The wood is then beaten until the cambium cells are crushed, when a skilful twist separates the bark from the wood, as a

Making a Whistle.

hollow cylinder that can be slipped off the end of the stick.

230. Inasmuch as the new material is all formed from the cambium, and this lies between the wood and the bark, it is quite evident that the newly-formed wood must lie outside the old wood, while the young bark lies inside the older bark. As a result of this the old bark, which fitted the old trunk, must stretch as new bark and new wood are formed beneath it. This it will readily do for a number of years, but finally, being cut away from the inner nourishment, the outer bark loses its elasticity, and then it becomes split and broken. Everywhere through the bark are minute breathing pores, and the size, shape, and distribution of these are the main factors in deciding whether the bark shall split up and down, like the hickories and oaks and chestnuts, or crosswise, like the birches and cherries, or simply gradually crumble off, like the beeches.

Why the Bark Cracks.

231. But while it is true that in the great majority of plants the stems thus serve to lift the leaves into the air and sunlight, others behave as if less imbued with a sense of their duty and more and more inclined to shirk it. Thus many blackberries and raspberries, after a little growth, bend over and reach the ground. As these sway in the wind they rub a groove in the ground, at the same time often wounding the bark of the twig. From such places roots are very apt to spring and the tip is anchored and ready to start a new growth. Other stems, like the ground ivy, have become quite prostrate, rooting at practically every joint; only the tip turns up, with its cluster of leaves and of flowers, for the flowers must catch the eyes of the insects.

Stems that Lean.

232. Still others without giving up their struggle after light and air have not the vigor which would hold them erect. Accordingly they have taken to holding on to their more robust companions. Whether they simply twine about their host or hang on by tendrils or by roots springing from along the stem, they gradually clamber over the host, often so shadowing its leaves with their own as to completely light-starve the supporting plant.

Vines that Hang.

233. A few unusually lazy plants, like the dodder, that yellow thread-like vine that so often entangles succulent herbs by the water's edge, not content with resting on their helpful neighbors, eventually have come to thrust rootlets into the very veins of the host. With almost diabolical accuracy they seek the pipes that carry prepared sap, and on this they live. Of course this renders their own leaves unnecessary, and this is true as well of the green coloring matter itself. Accordingly these parasitic plants have become yellow and leafless.

Robber Plants.

234. It is the leaf, that is after all, the crowning glory of the plant. Nothing but the abundance of leaves on every side prevents us from realizing their wonderful beauty. We think of flowers as having the greater charm. But a tree all flowers is only beautiful if embowered amongst trees all foliage. If the flowers were the common and leaves the rarer spectacle, we would turn with delight to the quiet, cool restfulness of foliage. The leaf, too, is by far the most industrious part of the plant. The life of the root is more subdued, more passive; but the leaf labors with intense activity during the day and then spends the night clearing the scene of action for the work of the following day. On the activity which is

The Importance of the Leaf.

carried on chiefly in the leaf, all the life of the world, both animal and plant, is directly and immediately dependent; for the leaf absorbs sun power and packs it away in the starch and sugar it builds up in the leaf.

The Leaf a Transformer of Power.

235. Now while it is true that any green part of the plant has this faculty of storing up sun power, this is very especially the work of the leaf, which is thus a device for catching sunlight and converting it into forms of power useful for performing the life activities of animals and plants. It is because animals and plants use the food the plant has packed away that they have power.

The Light-catching Arrangement.

236. This is the reason for the regularity with which leaves are arranged on the stem. An examination of any young, vigorous, erect-growing twig will show what pains nature takes to see that each leaf shall get the largest possible share of sunlight. It is a matter of common observation that plants grown in a window become one-sided. Looked at from the room, a set of spindling stems forms a very uninviting view. Looked at from the outside of the window, and this is the sun's point of view, the leaves crowd and jostle each other like a bevy of children looking out to see the circus go by.

Opposite Leaves.

237. In some plants, the maples for instance, the leaves spring in pairs from the opposite sides of the stem. The lowest, of the year's growth, have the longest leaf-stalks, and these hold their leaves farthest from the stem. The pair next above stands at right angles to these and the leaves do not extend so far out. The third set stands over the first but with much shorter stalks so as not to overshadow the first. The fourth pair is over the second; and this plan con-

tinues to the top. Below the last year's growth the twig has branched, and any leaves formed there are carried far enough from the stem to escape being screened by those above. While this is true for upright stems, and most stems seem contrived to fit upright growth, when the branches start out horizontally the plan is modified. The leaves still spring from the same points as before, but they bend and twist their leaf-stalks until they bring their blades at right angles to the direction from which the largest amount of light can reach them. We rarely notice the excellence of this arrangement, for we commonly see trees and shrubs from the side, while the sun looks at them from above. But so soon as we take the sun's view point, we realize how beautifully leaves arrange themselves, and this arrangement is quite possible of easy readjustment. If a twig be broken out of the mass, it is astonishing how soon the opening is utilized. Leaves take advantage of the opportunity, crane their necks until their broad faces catch the new flood of light, while others, farther in, that would under the old circumstances hardly have grown to any size, now put out full vigor, and they, too, set their faces steadfastly to the sun.

FIG. 33—OPPOSITE LEAVES

238. In many other plants a somewhat different

plan is followed. Instead of two, but one leaf springs from any one level. A line drawn through the successive leaves would trace a marked spiral on the stem; each leaf has a definite angle of deviation from the one below it. Sometimes the second leaf is half way around the stem from the first but on a higher level, then the third leaf comes over the first, the fourth over the second. This is the common arrangement on corn, wheat, and indeed on all the grasses. In the sedges, each leaf is one-third of the way around the stem from the one below it, bringing the fourth leaf over the first. In very many trees, the apple for instance, the sixth leaf is over the first, the spiral having gone twice around the stem meanwhile, and each leaf being two-fifths of the way around the stem from the preceding one. The order and regularity of this arrangement is not more astonishing than the ease with which the plant adapts it to the immediate situation, by twisting and bending itself, by suppressing some of the leaves and strengthening others, and by bending leaf-stalks. All this is apparently for the sole purpose of putting the leaves at right angles to the direction of the sun's rays, that they may do their share of this wonderful work of absorbing power.

Spiral-set Leaves.

FIG. 34—SPIRAL-SET LEAVES

The Birch, Cardinal and Fern Love a Moist and Shady Nook

239. Not only is the arrangement of the leaves on the stem adapted to catching the sun's rays, but the very structure of the leaf itself is plainly arranged for the same important purpose. Should the circumstances require it, a slender leaf-stalk holds the flattened blade out into the light. Such a leaf-stalk must evidently be provided with different fibres and with tubes to carry both crude and rich sap between the leaf and the stem. The stalk is continued usually as the midrib of the leaf, which branches into smaller and smaller bundles until it finally becomes a minute network. Between the meshes of this network the living tissue of the leaf is spread in a layer usually not more than one one-hundredth of an inch in thickness, and often much less. Over all of this is a thin skin, on upper and lower surface, called the epidermis. In the lower epidermis are many mouths, each guarded by two lips, which open or close, depending on the condition of the air outside. When the atmosphere is very dry and evaporation from the leaf would be rapid, producing wilting, the mouths close very tightly. But when the atmosphere is damp, the lips curl back and allow the circulation of air into and out of the mouth to go on unchecked.

The Flattened Leaf.

240. On leaves thus spread the sun shines day by day, and the power hidden in the sun's rays is locked up in the leaf, chiefly in starch-and-sugar compounds. This starch is built up in the leaf from crude materials brought up from the root and taken in from the air. With this starch is tied up the energy of the sun's rays that fell on the leaf, much as power is locked up in gunpowder. All day long the starch accumulates, so that by nightfall the leaf is quite loaded with it. During the night the starch

Starch is Stored With Power.

is changed to sugar and carried down the leaf-stalk and throughout the stem, furnishing new material for growing parts, or being changed back to starch and stored away in the crevices of the stem or the root where there is no immediate necessity for it.

Modified Plant Parts.

241. The three parts of the plant thus far described,—that is, the root, the stem, and the leaf,—are in reality the only parts a plant possesses. All other apparent portions are really modifications of one or other of these, and no small interest lies in determining what part any one example may really be. A potato, though under ground, is a stem,

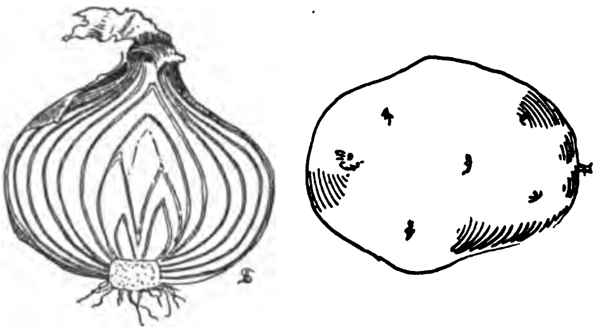

FIG. 35—UNDERGROUND STOREHOUSES

for it has buds, the so-called eyes, at definite intervals. The underground fleshy portion of calamus is a stem, being markedly jointed, and the roots being comparatively slender offshoots of this stem. In an onion the roots are the slender fibres; the stem is a short flattened portion at the base of the bulb itself, while the coats are the altered leaves, rendered fleshy through serving as an underground storehouse.

242. Thorns, though of course without consciousness on the part of the plant, have arisen under natural

selection as defences. Drought, especially, has a double effect; it tends to produce wiry and hard plants, and it makes animals more eager to eat those that remain edible. In this way certain plants have, generation by generation, become very tough and briery, and have eventually made those thorns what we see them. It is particularly interesting to notice that so long as a thorn-bush is closely cropped by sheep or cattle, it tends to become not only dense but very thorny. But keep cattle from the pasture until the thorn-bush has grown out of their reach, and the upper part of the plant grows more open and has far fewer thorns.

Thorns as Defences.

243. A still more effective defence on the part of plants lies in the formation of poisons. Probably they were originally simply waste matters; but such plants as developed offensive or noxious wastes gained in the struggle until whole families now sometimes share more or less in the possession of such a characteristic. The pungent flavor of the mustards, the aromatic odor of the mint, the rank character of the onions and garlics, are the milder beginnings of the habit that ends in the production of morphine, strychnine, and cocaine.

Defensive Poisons.

XVI

REPRODUCING THE PLANT.

244. THE most interesting of all the modifications of the plant parts is seen in the flowers. Here we have a short branch, its leaves crowded closely together and greatly modified until they subserve an entirely new purpose. That the flower parts are modified leaves is easily seen from the frequency with which many of them revert again. The sections of the outer, greener circle, the calyx, are often leaf-like in roses, in catus flowers or in water-lilies, while in the last two the transition between calyx and corolla is so gradual as to make the line of distinction imperceptible. In double carnations the stamens constantly grade off into petals, with a dozen intermediate steps, all in the same flower. In roses, peaches, and pears, finally it is no uncommon matter to find the pistils reverting into leaves.

The Flower an Altered Branch.

245. In order to make the explanation of the flowers more clear and definite, I shall describe the common garden nasturtium. This is so well known, so easily obtained through so much of the year, so large in its parts and so clear in its meaning, that it will serve quite as well as any flower we could select.

The Nasturtium.

246. Let us begin with the bud, which nestles on its short stem, a green thing hidden amongst green leaves. Here nothing is seen of the flower but the outermost circle of leaves, changed, to suit this purpose, into what is called a calyx, the individual leaves being known as sepals. Within this, as yet

The Nestling Bud.

enfolded in their calyx, are the rest of the flower parts, still minute and often folded and crumpled. In this stage the young tender bud would be delicious eating

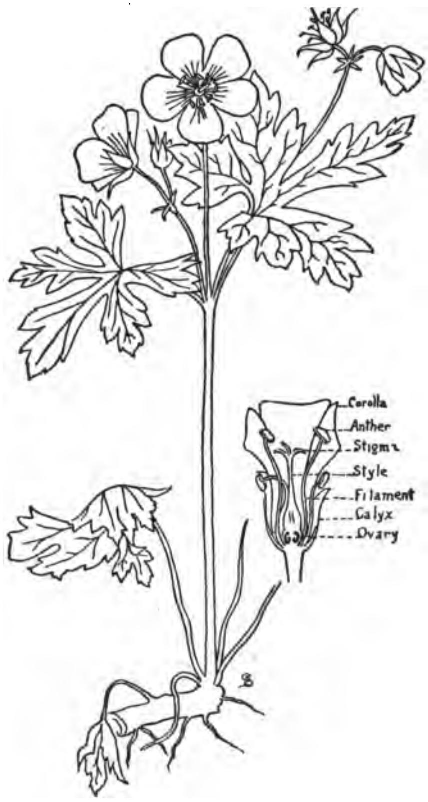

FIG. 36—THE PARTS OF THE FLOWER

to many an insect, and hence must be protected in every possible way. In the nasturtium this is secured by its nestling habit, its green color, and quite probably by its pungent taste, which, while it is only slightly

biting to us, would probably be far different to an insect to whom a single leaf of the nasturtium is food enough for several days.

The Defensive Calyx.

247. In the rose the toughness of the sepals is their best means of defence; in the laurel, it is their stickiness. That this early protection of the bud is at least one important if not the chief use of this circle of leaves, is shown by the fact that certain flowers, blood-roots for instance and their relatives the poppies, drop their sepals almost as soon as they open.

The Attracting Corolla.

248. But it is the next whorl of leaves that is the conspicuous one. When all is ready, the calyx turns back and discloses the next circle of transformed leaves, the corolla, each individual leaf being known as a petal. It is to the infinite variety, in shape, in color, in markings, and in development, of the various leaves of this circle that flowers owe their consummate beauty. In the nasturtium the various colors are the result of variation and of selection under cultivation, but after all they are just variations on the orange yellows with redder color-patches and lines that mark the flowers of the plant in its native home along the damp gullies of the Andes. These markings at first sight might appeal simply as additional ornamentation. But they are very definitely located and are very suggestive.

The Guiding Patches.

249. The general yellow coloration of the flower serves to catch the eye of the passing bumble-bee or butterfly and lures it to the spot. When the insect reaches the immediate neighborhood of the flower, the color-patches on the three lower petals indicate to it just where it is to alight. The flower may be turned more or less to one side or

the other, so that any one of the three lower petals may stand in proper position to serve as a landing stage. No sooner does he reach the place than a fringe near the base of each petal confronts him and tells him to go no further. Meanwhile, opposite his eyes, on the two upper petals and on the calyx, a series of distinct lines point the way directly toward the opening into the long spur at the back of the calyx. Here lies the nectar, which the bee wants and which the flower has prepared for its express benefit. Accordingly he slants forward his tongue, which has been lying back beneath him against his breast (for insects do not draw in their tongues) and guided by these lines he runs his tongue down the tube. Unless he happens to be short of tongue or the flower is too long of tube, he reaches the precious fluid and draws it up into his crop. I said the flower had put it there for the bee. This is not because the flower is impelled by benevolent feelings, but because it is good for the flower that the bee should visit it.

Long Honey Tubes.

250. To this part of the story we will return later; meanwhile, a glance at a few of the other flowers will help us to understand more of the infinitely varied plans for securing the same end. Scarcely a child but has plucked the flowers of the familiar woodbine or honeysuckle vine, and slipped its tubular corolla over its slender pistil until the nectar appeared at the back, and then has delightedly sipped the little drop of sweet fluid. These flowers, with long and slender throats, are adapted only to the visits of such creatures as have tongues equally attentuated. These are chiefly butterflies and certain of the bumblebees, together with the most beautiful and daintiest of them all, the humming-bird. The sages and the morning-glories, the thistle and the red and crimson

clovers, are of this sort. A peculiarity of shape such as this keeps away most insects, their tongues preventing them from feeding, here as effectually as did the size of head in Æsop's fox prevent him from dining with the stork from a long-necked vase.

The Moon-flower and Its Long Throat.

251. This trick of forming a long and slender corolla tube finds perhaps its finest exemplification, in our neighborhood, in the moonflower. This beautiful member of the morning-glory family has a throat about six inches long and so narrow that it is out of the question for insects to creep down its great length. Besides, it blooms at night, when most honey-loving creatures are fast asleep.

The Long-tongued Hawk-moth.

252. But probably no bright-colored flower in its native home is without some provision for nectar-loving visitors. Such flowers as the moonflower, the petunia, and the "jimpson" weed have brought about a strange transformation in the branch of the butterfly group known as the hawk-moths. Instead of flying by daylight, as do the true butterflies, they fly in the twilight and on into the night. Their wings are long and slender and move rapidly, as do those of the humming-bird. This gives them the power to poise in the air. Added to this is a remarkable length of tongue. Few even of this group can reach to the bottom of the moonflower, which must depend for its pollination chiefly on the visits of the five-spotted hawk-moth. This is the adult form of the "green worm," the larva with a horn on its tail, that infests the growing potato, tomato and tobacco plants. Its muscular tapering body gives it great powers of rapid flight, and the ability to poise, motionless except for its wings, which quiver so rapidly that

they are nearly invisible. As evening comes on, the moonflower untwists its pointed buds with a rapidity of movement so unusual in a plant as always to strike the beholder with delight and often with awe. With the unfurling of this guiding signal, intended to catch the eye of a roving hawk-moth, the flower emits a prevading sweet odor which is attractive to a sense which in most insects is more sensitive than sight, the sense of smell. Lured by this double stimulus, the creature approaches on rapid wing, hovers lightly before the flower, unrolls a tongue six inches long, and deftly inserting it into the central opening of the flower, probes its slender depths for its reward of luscious nectar.

FIG. 37—THE NASTURTIUM'S HONEY GUIDES

The Necessary Organs.

253. But this corolla of the flower, beautiful as it is, and forming as it does, the main attraction to our eyes, is entirely secondary in its importance to the flower. For a long time after the introduction of the seed-bearing habit into the plant, wild flowers had no alluring corollas, and many of them are still without that attractive addition, as witness the cones of our pines and spruces and the spike in the grains. Entirely inside the attractive rows of leaves are two other circles, transformed so long since, for so definite a work, that they have lost all external resemblance to the leaves in which they originated. These two rows, the stamens and the pistils, are the only

members absolutely necessary to the seed-producing function of the plant.

254. The stamens form the first circle of these indispensible members, lying between the corolla and the pistils. Each stamen has usually a slender stem, technically known as the filament, and ends in a head, usually of two oblong compartments and known as the anther. In this anther is produced a great abundance of pollen. This is made up of separate grains, usually not more than a thousandth of an inch in diameter and commonly of a powdery consistency. In each one of these grains lies the possibility of half the responsibility for a seed. The other half of that responsibility lies in an ovule, in the base of a pistil of some flower of the same species of plant as that which bears the pollen. This is most commonly not in the same flower, very often, and perhaps best, not on the same plant. The pistils are the central organs of the flower, sharing with the stamens the great function of producing seed capable of growing into a new plant, whose great merit, or perhaps sometimes defect, is that it bears qualities derived from both parents.

Stamens and Pistils.

255. In the pistil it is usually easy to make out a swollen base, the ovary, with a hollow chamber inside of it. This chamber is quite well filled with what seem to be small seeds attached to the wall of the chamber, usually along a projecting ridge. These apparent seeds are really ovules, which under proper coöperation on the part of pollen grains, have the power to become seeds. From the tip of the ovary projects commonly a slender stem, the style ending in an enlarged head, the stigma, which at one stage of the blossoming becomes sticky with an exuded fluid. It is the work of the stem to hold this sticky head

The Parts of the Pistil.

in such a position that by some means or other (the method varying with different flowers) there may lodge upon it a grain of the stimulating pollen.

256. If now we will follow our familiar nasturtium through its blossoming period, the meaning of this complicated arrangement grows clear. While the buds are getting ready for the great day, they nestle closely amongst the leaves, green in color to be less conspicuous, and sharp in taste to discourage browsing animals. But when all is ready within the blossom, the stem lengthens, thrusting the flower up through its shelter of leaves.

The Nasturtium and the Bee.

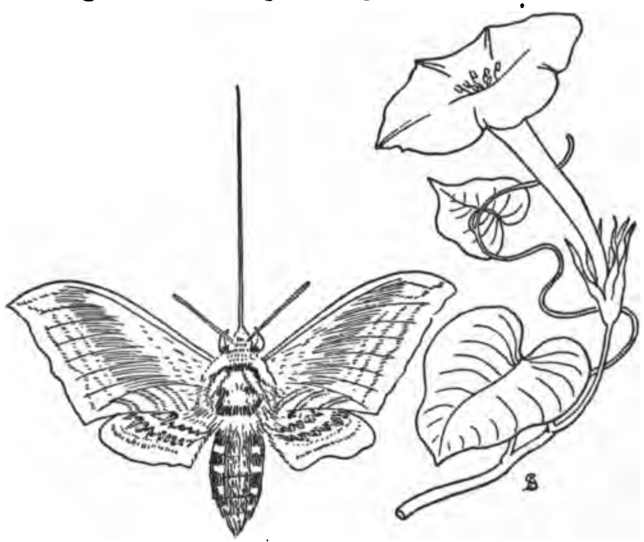

FIG. 38—THE HAWK-MOTH AND THE MOON-FLOWER

Then the calyx bursts open and the orange-colored petals unfold. The roving bumble-bee, attracted by the brilliant color, sits down on the crimson stain on one of the lower petals. A bristling fence warns him

not to enter the throat of the flower, but beyond it the dark lines of the upper petals furnish ample directions and bid him thrust his tongue into the hole toward which they point. This leads down into the long spur, and the slender tongue of the bee, probing its depths, draws up the nectar from the bottom of this slender vase. So far as the bee is concerned, this is the whole of the process, and away he goes to the next nasturtium to get another precious drop of the same flavored nectar. For his crop will carry back to the hive the nectar of twenty blossoms, and his palate is averse to the mingling of flavors that would come of mixing the secretions of different kinds of flowers. But from the standpoint of the flowers, much is still to be done. As the bee leans over the fence, the upcurving stamens dust the fur on the under side of his throat with yellow pollen. In this flower, and perhaps the next, the pistil is not yet ripe and sticky, but before he has gone far he comes to a nasturtium whose pistil has split into three prongs and these are covered with a tenacious fluid. Pressing under the chin of the bee, it picks from the fur the yellow dust and the flower now has its reward for the trouble it was at in furnishing the showy corolla and the alluring nectar. These now disappear, and with them the calyx and the stamens, for their share of the work is done. Not so with the pistil. The pollen grains attached to the sticky stigma begin to sprout. Down the slender stem each tube-like thread insinuates itself, enters the chamber at the bottom and gropes about until it finds the opening into the heart of an ovule. Into this it grows, and then the nucleus of the pollen grain, with its power to impart the qualities of its parent plant, slips through and fuses with a similarly dowered nucleus in the centre of the ovule. These two

now develop and stimulate the ovary to grow into a fruit and the ovules into seeds.

257. Why should nature go to so much trouble when portions of the root or of the stem of the plants would have served quite as surely to produce new plants? Man plants slips, and bulbs, and tubers and roots; sets grafts, and plants runners. Why does not nature rely more frequently on such methods? The answer lies in the fact that nature ever wants some new thing, stronger and better than she had before. By growing her plants chiefly from seeds, she secures a double parentage for each plant, and in these new combinations of ancestral traits lie the potentialities of all manner of improvement. Of course, possibilities of the new forms being weaker instead of stronger are just as abundant. But nature never troubles herself on that score. The trials of life are severe enough to cut off all the weak and puny plants, while these same difficulties only serve to increase the advantage of those plants which are more than commonly hardy.

Why Plants have Two Parents.

258. The relation just described between insects and flowers is one of the most interesting subjects which comes into the scope of nature study. A short examination of a few common flowers will help the learner to look into the face of any of our flowers and read the story written there.

Insects and Flowers.

259. One of the most successful of the wayside weeds is the yellow "butter and eggs" or toadflax. This belongs to a group of flowers often called snap-dragons because their petals are so arranged as to look like a closed mouth, which a little pressure on the side serves to open. Such

"Butter and Eggs."

devices serve to keep out marauding insects, particularly ants, while offering no difficulty to the legitimate visitor.

260. Ants are particularly disadvantageous to flowers. They are fond of sweet fluids and so would steal the nectar, but they fail for a double reason to carry the pollen. In the first place, they are so small that often in going to the nectar they would creep under the stamens and never come into contact with the pollen-bearing anthers. In the next place, they have smooth coats to which the pollen is unlikely to adhere and from which it would most likely be brushed in their long and tedious journeys from flower to flower.

Flowers Ward Off Ants.

FIG. 39—THE TOADFLAX

261. In the case of the toadflax, the lemon-yellow spike of flowers attracts the eye of the roving bumblebee as he approaches, and the orange patch on the swollen lower lip tells him where to alight. No sooner, however, does he throw his weight upon the portion of the corolla than the flower opens wide its mouth. Just before him, on the lower lip, is a double line of bristling hairs with a smooth groove between them. Into this depression he puts the tip of his tongue and forcing it forward it enters the spur containing the nectar. At the same time the crossed anthers, lying in a hollow of the upper lip, have dusted his head with the pollen which it is his duty to carry to the next toadflax flower. No sooner does the bee take his burdensome body from

Fertilising Toadflax.

the lip of the flower than the mouth closes and prevents less bulky visitors from intruding.

262. The flowers of the mountain laurel have an angularity quite uncommon for objects so graceful. The reason is that each of the ten stamens is bent like a spring, and its head is inserted in a little pocket in the corolla of the flower. When the visiting insect probes amongst the bottoms of the stamens for the nectar secreted there, he disturbs the stamens and one after another they shoot out

The Snapping Laurel.

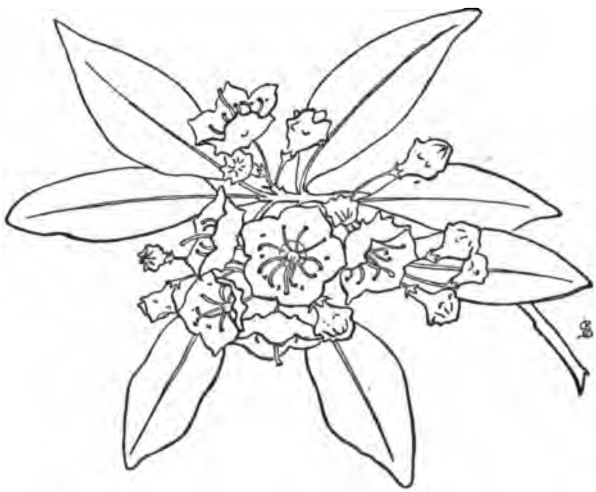

FIG. 40—THE LAUREL'S POLLEN SPRING

of the pockets with a sharp flip and throw the pollen upon the body of the visitor.

263. More complicated than any of these is the mechanism used by our commonest blue violet. The bumblebee, once more, is the visitor to this flower. The blue color of the corolla is again the attraction from afar. On near approach a yellow spot, emphasized by white

and blue lines in the centre of the flower, shows the point of insertion for the tongue of the bee, which, by the way, bends over the flower from above the opening.

The Violet's Hopper.

The five stamens touch each other in such a way as to make a box around the style of the pistil; and when they split and discharge their pollen it remains in the box. Each of the two lower stamens has a projecting lug and these are so curved as to leave a small opening between them. This hole is so placed that the bee's tongue, pushed into the centre of the flower, enters this opening between the stamens and pries them apart in its onward course to the nectar which lies just beyond. Pushing apart these stamens means opening a slit in the bottom of the box of pollen, and the fertilizing dust drops under the chin of the bee. He carries it to the next flower, whose curved stigma is appropriately placed to pick off the pollen as the bee turns himself upside down to get the new portion of nectar.

Fig. 41—The Violet Pollen Hopper

Fig. 42—The Coöperative Dandelion

264. There is an interesting form of economy which many flowers practise. The corolla, useful as it is, is useful only for a few days at the most, and is then thrown aside. Accordingly, many plants have come to gather their flowers into clusters. In this way each flower

only needs a small corolla and they help each other. This tendency is carried to the extreme in the daisy family. Here many flowers gather together into one composite flower. This is the plan used by the daisy, the dandelion, the thistle, the golden-rod, and many other common plants.

Coöperating Flowers.

265. We have seen how the various parts of the flower coöperate and have for their clear purpose the production of seeds. A flower that produces no seeds withers soon after blossoming and falls to the earth. If, on the contrary, the flower has succeeded in becoming fertilized, certain parts, whose work is now accomplished, fall away. The petals, which are the conspicuous parts of the flower, drop off; usually the stamens also curl up and wither; sometimes the calyx drops. But at least the ovary and often other parts of the plant attached to the ovary remain, when the rest of the flower has been cast aside. Here, hidden securely, are the seeds, and this mature ovary, with any part that remains attached to it, is known as the fruit. The word "fruit" has a somewhat different meaning in science from that which popularly attaches to it. In the ordinary understanding of the word, fruit must be good to eat, there must be pulp about the seeds. To the scientist any case, whether pulpy or dry, that holds the seeds, is a fruit. In this matter the nature student may well side with the scientist. It is very commonly the case that these fruits are dry, inconspicuous, and entirely uninteresting as articles of food. Practically nothing eats them except hard-billed birds, who take them for the seeds which are in them, and insects which burrow into the seeds. Other fruits are rich and pulpy, with brilliant color, enticing odor and luscious taste. But these are not more truly fruits

Fruits Follow Flowers.

than the dry and unenticing ones. The great purpose of the fruit is the protection and perhaps the scattering of the seeds.

266. The worst possible place for a seed to be planted is just beneath the plant which produced it. There can be no fertile ground worse adapted to its growth than ground on which the same sort of plant has grown before. For some reason or other, the soil that has just grown wheat is not well adapted to the growing of more wheat. The farmer has known this fact and acted on his knowledge for years past. The reason for it he probably never asked himself until within comparatively recent years. It was enough for him that experience had taught his ancestors and that they had told him that there must be what is known as a rotation of crops. Then came the explanation of this need for rotation. Man began to analyze the soil by chemical methods and to find that plants take certain materials from the ground. They found that different plants take somewhat different materials from the soil; that the materials which wheat abstracts are not identical entirely, at least in proportion, with those taken by corn. From this we leaped, perhaps too hastily, to the conclusion that when wheat had grown in a certain field, the soil of that field was practically exhausted of the sort of material needed for the formation of wheat. Hence wheat planted here the following year would starve for lack of sufficient food, but corn needing a different proportion of material might still find in the soil an abundance of food which was necessary for its purpose.

Why Rotation is Necessary.

267. This seems so entirely reasonable and such a natural deduction from what we had learned that until recently it was hardly questionable. But the last few

years have brought serious questions of the truth of these conclusions, and some of our botanists, particularly those connected with the Department of Agriculture at Washington, have been giving us a new explanation. They have analyzed the soil on which wheat has been grown, and they find that in many instances, if not in all, there still remains in the soil in soluble form all the materials necessary for the upbuilding of wheat. The failure of wheat to thrive upon this ground, so they tell us, is certainly not due to starvation. Their explanation is that wheat, in its growth, sends out into the soil certain waste materials which load the soil and eventually make it poisonous to the sort of plant which threw out these wastes. Other plants are often, though not always, unaffected by the wastes of wheat, and therefore are well able to live in this soil, which in turn they load with their own wastes. So the third year another crop is planted, after which it may be quite possible that the wastes left by the wheat three years before have altogether disappeared and the soil is now adapted once more to growing wheat. Whatever may be the reason, there can be no doubt of the fact that a plant does not commonly thrive well where other plants of the same species have grown before.

Plants Pollute the Soil.

268. One of the very simplest methods for scattering seeds is that taken by the touch-me-nots. The common garden balsam or so-called lady-slipper is a touch-me-not; while in summer-time creek-sides and often even the gutters by the road-side have a wild touch-me-not known as jewel weed. These bear flowers shaped like little yellow trumpets, hung up by their sides. When the flowers of this plant have disappeared there remain long slender pods, rather glassy looking

Snapping Fruits.

like the stem. When these are quite ripe, if one simply shakes the plant the ripe fruit suddenly splits and curls and snaps away the seeds so that they fly for at least three or four feet in every direction.

The Witch-hazel Fruits.

269. Those who visit the woods in November often come home with twigs of the strange yellow flowers of witch-hazel. On these same stems will doubtless be found the fruits of the last year. On putting these twigs into a vase, one is often startled after several hours, and frequently in the midst of the night, to hear a crack and a rattle. On looking about to see what is the trouble, it is found

FIG. 43—THE SNAPPING WITCHHAZEL

that the witch-hazel has split its fruits and thrown its seeds with much force to a distance of at least eight or ten feet:

270. A very much larger number of plants depend upon the wind for carrying their seeds. If one will but lay bare a patch of ground and leave it uncultivated for a single summer, he will find that a considerable variety of plants will grow up here. On looking at the method by which these plants could have arrived

where they are, one is surprised to find how many of them have wind-carried seeds. Let fire sweep a clearing on the Pennsylvania mountains and it is very likely that the patch will soon be overgrown with white lettuce, while in northern New York, under similar circumstances, a

Wind-Carried Seeds.

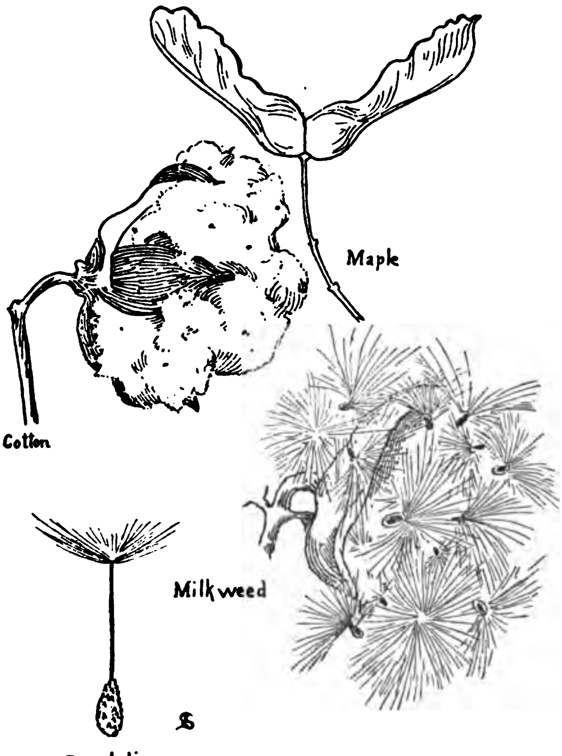

FIG. 44—WIND-BLOWN FRUITS

beautiful patch of fireweed, doubtless so called from this habit, is more likely to spring up.

271. One of the most conspicuous cases of wind transportation of seeds we find in the case of the maple. Every one is familiar with the fruit of the maple, with its heavy head and its vane with a heavy rib on one side. It is this heavy rib which is the saving of this fruit. If it were not for this, with its heavy head and symmetrical vane about it, the maple seeds would be veritable arrows and would shoot out of the tree directly to the ground beneath. But unevenly weighted as these arrows are, with their heavy rib on one side, their whole manner of flight is altered. The wind shakes the fruit loose from the tree and the unevenness of the vane makes it twirl. The result is that it is slow instead of rapid in reaching the ground, and consequently the same wind which shook it loose has abundant opportunity to carry it some distance away from the parent stem before it strikes the ground.

The Maple Keys.

272. Perhaps there is no more beautiful illustration of wind-carried seeds than the fruits that go sailing away from the dandelion head. Every dandelion fruit, and there are hundreds of them on a single large head of dandelion, consists of a case at the bottom with one seed in it and with little teeth projecting from its upper end. This end is continued into a slender stem from the tip of which radiate light fluffy hairs. When the dandelion has blossomed and succeeded in fertilizing its ovules these remain closed up in its green head for a number of days until the fruits are thoroughly ripe. Then comes a day just warm enough and bright enough for the planting of dandelions. The green circle around the head turns back and the head itself swells up into a great white ball from which extend in all directions the beautiful

The Wind-sown Dandelion.

fluffy fruits. Now comes a fresh breeze and one of these little fruits, breaking loose from its hold on the stem, is carried away dancing and floating in the air and the sunlight. After a while it settles down slowly, as the wind grows less brisk, and the fruit begins to strike the ground. If it strikes a hard place it cannot catch hold, but when it happens to drop its heavy fruited end into some slender crevice in the earth, the little teeth catch hold of the sides of the crevice and keep it from being torn out. Indeed the prongs are so adjusted that every time the hairy top waves the seed is forced deeper and deeper into the crack where it thus finds suitable lodging.

The Down of Cotton.

273. One of these wind-blown seeds has come to be highly prized by man on account of the use which he has learned to make of it. The cotton plant of the South has a flower which looks much like the hollyhock. When this has blossomed and ripened its fruit, this fruit takes the shape of a round capsule which is full of seeds, each seed being wrapped in a great mass of white hair which is what we have come to know as cotton. This fluffy mass of hair is intended by nature to carry the seed into a new position and there allow it to grow. We have found it to our advantage to comb the hair off the seeds and spin it up into thread and weave it into cotton cloth. While of course it is perfectly proper that we should do so, it is rather an egotistical point of view which believes that this is what the cotton is intended for.

274. If one wishes to see what a host of plants scatter their seeds by means of the wind, he need only go some pleasant afternoon in late September to the edges of a moist thicket where the bank spider has spun its splendid orb-web, and see what a multitude of seeds

have been caught by a single web as they wafted through the air. Or let him lie beneath the shade of some clump of trees where he can look through an open place into the blue sky. He will be greatly surprised to notice how the September air is loaded with these dainty craft.

Watching for Wind-blown Fruits.

275. One of the very effective methods which some plants have learned to use, is that of attaching themselves to passing animals and thus being carried. These seeds are almost always dull and unobtrusive in color; the animal never notices them until he has run up against them, and when he has done this he leaves the plant, carrying with him the seeds. Any one who owns a setter dog has more than once, after a long day's tramp in the fall, combed from his dog's long ears and from the abundant hair of his legs and tail a great mass of these clinging fruits.

Animal-Carried Fruits.

276. Almost every country child has made from the burrs of the burdock, while they are green, models of one sort and another, commonly birds or baskets. These burrs need only be pressed against each other to hold on tightly. This is because every point which surrounds the mass ends in a little hook. These hooks are turned inwards while the burr is still green and do not affect the passerby. When the plant is fully matured and the burrs are ripe, each point curls back and sets out its hooks in such fashion that one need only push against it to have it stick itself firmly to his clothing, especially if that clothing be made of wool. The cow is one of the best contrivances imaginable for planting burdocks. She passes a burdock plant swinging her long hairy tail and it strikes a bunch

The Burdock's Hooks.

of the hook-covered balls. Every one of these brown fruits clings to the curled hair of her tail and she passes away burdened with them. All day long she swings her tail, perhaps all the more vigorously because of the

FIG. 45—CLINGING FRUITS

additional weight of the burrs, and as she does so gradually the burrs break apart, seed after seed is thrown to every side, and by nightfall most of the burdocks have been planted.

277. Perhaps the best known of these clinging seeds is the one known as Spanish needles and beggar ticks. This plant bears a flower that looks like a little small and ill-developed Black-eyed-Susan. When the flower has bloomed and the fruit is formed, the whole head becomes brown and inconspicuous, and we in our walks push into it without noticing what we are doing, but we quickly pay for our negligence. Each slender fruit in the cluster is tipped with two or more points, and these points have small barbs. They readily enter into our clothing but the barbs prevent their withdrawal. We walk away, perhaps for a long time unconscious of the fact that we are engaged in sowing beggar ticks. In walking through an old pasture, it is not uncommon to find a string of beggar ticks growing on either side of any pathway that may run through the field. It would seem that the plant with diabolical intelligence had placed itself where man would be sure to run against it. Of course exactly the reverse is true. Men have walked that way for years and, year by year, have carried on their clothes the fruits of this plant, scattering them well on either side of the pathway.

The Beggar Tick.

278. There is often an interesting sequel. The path comes to a fence on which the person seats himself. While resting here on the topmost rail, the fact that his clothing is covered with these annoying fruits becomes evident and he cleans them off. No sooner has he done so than he jumps down into another patch which a predecessor has planted under exactly similar circumstances the year before. Meanwhile, he himself has planted a patch to annoy the unoffending wayfarer who will cross the fence at the same point next year.

Planting Beggar Ticks.

279. But the fruits that endear themselves to our hearts are the pulpy fruits. These seem to us as if they were made just for our purpose, and I think here we may safely agree that such is really the case. Of course they were not created exclusively for us, but for all other fruit-eating animals as well. This may seem like surrendering our philosophy, but it is not so. If this pulp is intended for us to eat, we may be sure that it is to the advantage of the plant that we should eat it. The man comes along and passes an apple tree; the season for apples has not yet arrived.

Pulpy Fruits.

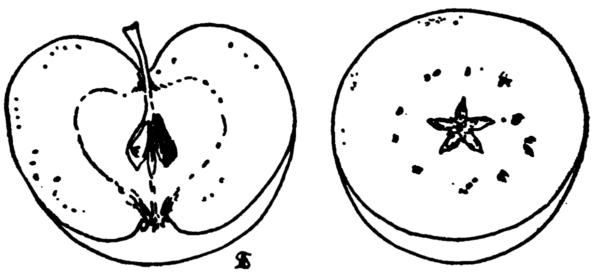

FIG. 46—THE TEMPTING APPLE

There is abundant fruit upon the tree, but as yet it is not ready for distribution, that is to say, the seeds within it are not yet ripe. Accordingly the plant does not wish its fruit to be seen and keeps it the color of the leaves amongst which it nestles. So uniformly is this the case that when we speak of green fruit quite unconsciously, we do not refer to its color for we call unripe fruit green no matter what its color. With unconscious contradiction we speak of a blackberry as green when in reality it is red. But after a while the seeds are ripe, and now the plant wishes to have them scattered. Each apple begins to grow redder in color. Red streaks and mottlings mantle its surface. More

and more they spread until finally the apple is well covered with red.

Sour Taste of Green Fruits.

280. Should man attempt to gather the fruit before the plant intends him to, on setting his teeth into its hard pulp he finds it not only sour to the taste but very indigestible. But when the plant is ready to have him eat it, the sourness has disappeared from the pulp and it has softened up and become toothsome. Now it is not only pleasant to the taste but nutritious and enjoyable. So he plucks the apple from the tree and goes on his way rejoicing. But when he has eaten well into the apple, it begins to remonstrate. His teeth find themselves in contact with the core. He turns to another side of the apple and feasts there and keeps on turning until he has eaten the pulp from every side down to the core. Now he throws it away, far from the place at which he picked it up. The plant has succeeded in gaining just what it wanted. Its fruit has tempted an animal to carry the seeds to a distant situation and has well paid him for so doing.

Small Fruits are for Birds.

281. There is a whole host of fleshy fruits which serve for the special delight of the birds, which render more efficiently than do mammals this service to the plant which feeds them. A cherry tree has seeds ready for distribution. Each seed is covered with a coat of pulp, attractive to the eye and pleasant to the taste. The robin comes along, picks up the cherry, flies to the nest, bites out the stone, and feeds the pulp to its older nestlings, scattering the seed on the ground beneath the nest.

282. A cherry seed is too large to be swallowed by a bird, but there are many fruits in which the plan is somewhat different. Such are the raspberry, the straw-

berry, and the blackberry. Here the seeds are very abundant and very minute but each of them is so small and so hard that it fails of being ground in the gizzard of the bird. The seed is accordingly soon discharged, undigested, by the bird, and dropped in situations sometimes many miles away from the spot in which the bird found the fruit.

Bird-sown Seeds.

283. I have recently noticed a very interesting case of bird distribution of seeds. From the car window I often see a large field in which there are two trees. One of these is a juniper tree, the other an oak. The juniper bears small bluish-white and very aromatic fruits, and of these several species of our birds are very fond. Many of these birds rest, if they do not nest, in the adjacent oak tree. I do not doubt that many juniper seeds are dropped by the birds, both underneath the juniper tree and underneath the oak. But because of the principles of rotation of crops (mentioned in sections 266 and 267), those under the oak tree flourish, while those under the juniper do not. The consequence is that beneath the oak tree there is a fine crop of young junipers.

Bird-sown Junipers.

284. But if the pulpy fruits were intended for animals to eat, the nuts, which are far more valuable as food, distinctly attempt to avert this calamity. The difference between the two cases is very plain, indeed. In the fleshy fruits, the seeds lie in the heart of the fruit. Sometimes the seeds are so small as to offer little temptation. If they are large enough to be attractive, they are commonly protected in some way. The peach, for instance, doubly protects the seed. It has around the seed a very hard shell; but, as if this were not enough, it adds to the

The Well-Stored Nuts.

seed a bitter taste. Indeed this flavoring matter is more than bitter; if taken in anything like large quantities it is distinctly poisonous. But in the nuts the meat is the seed; for man or the animals to eat the nut is to destroy the seed. Accordingly these fruits use every device to prevent themselves from being eaten.

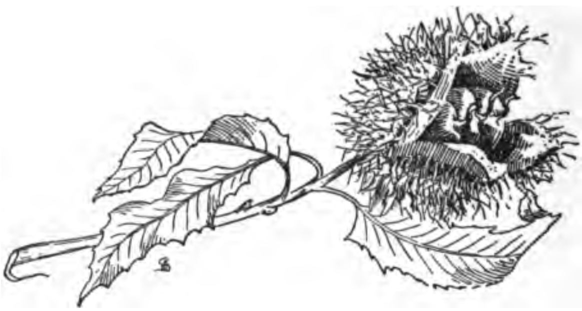

FIG. 47—THE PROTECTED CHESTNUT

285. In the case of the chestnut, a covering of sharp prickles invests the fruit on every side. When the fall comes these protected fruits, which tried to escape observation by being green amongst green leaves, now turn brown as the leaves lose their color. When the ground has lost its verdure, when the grass is brown and covered with the falling leaves of the tree, the burrs of the chestnut crack open and the brown fruits fall and roll into the crannies of the brown earth, thus escaping as well as may be the eyes of their enemies.

The Protecting Burr.

286. The walnut tries a different plan. While it is still immature it keeps itself covered with a hull so intensely bitter to the taste as to deter animals from eating and even to deter insects from laying their eggs upon it. A chestnut is often "wormy," but

walnuts and hickory nuts rarely have this difficulty. As the fruit matures, the coat around the seed grows harder and harder in the walnuts, and when once the seed is ready and toothsome there are very few animals that can get at it.

The Walnut's Bitter Hull.

287. Man with his fingers or teeth could do nothing. It is only because he has ingenuity enough to use tools that he is able to overcome the defence of this nut. Indeed, man with his brains is practically able to overcome almost all the defences of both animals and plants. It is in his being able to substitute brains for the specialized organs of other animals that his great superiority lies. He, with his brains, can outrun the deer, surpass the cow in digestion and the horse in the strength of the blow he can deliver.

How Man Opens Nuts.

288. There is one of the tropical nuts which has become so common an article of diet and is so well known that I think we may safely bring it within the range of our nature study, and that is the cocoanut. Those of us who only know the cocoanut as it comes into the market, do not realize that this familiar round nut when it hangs upon the tree is covered with a dense coat of coarse interlaced fibres covered on the outside with a thick shell. This makes a fruit twice as large as the cocoanut as we know it, and makes of it a light rather than heavy nut. Cocoanuts grow upon palm trees, and in a palm all the leaves as well as the flowers and the fruit are at the top of the trunk. When the cocoanut is ripe a drop like this of thirty to fifty feet would crack the nut did it not have about it this fibrous husk. This breaks its fall and leaves the kernel unharmed. Furthermore, should this fruit roll down the banks of

The Cocoanut's Heavy Husk.

a stream, it is light enough to float upon the water, thus it may be carried further down the stream to spring up there. Or it may go farther still; it may be carried to the ocean and wafted to some neighboring coral reef, there to take root. It is one of the interesting conclusions of a recent botanical study, that the cocoa-

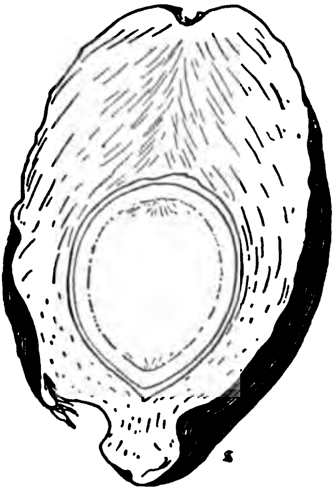

FIG. 48—THE WELL PROTECTED COCOANUT

nut is native to the western coast of South America, though it has now nearly disappeared from this locality. But the waters of the Pacific equatorical current have carried this fruit across the ocean and spread it to island after island. The islands of the Pacific are now the most prolific home of the cocoanut, which as stated, has nearly disappeared from the home of its birth.

XVII

THE HEAVENS

289. It has always been a matter of surprise to me that so few people seem to know anything about the heavenly bodies. They are so constantly present to our view, and are so beautiful, that one would think them likely to be objects of much interest. In times past, when the stars were believed to shed an "influence" upon men's lives, and the moon's phases were supposed to affect man's crops and indeed many of the events of his career, it is not remarkable that much attention should have been paid to them. But it is a pity that with the passing of superstition there should also have passed all popular care for these interesting accompaniments of our daily lives.

Waning Interest in the Stars.

290. A few observations on the Sun and the Moon, our near neighbors, and an acquaintance with a few of the more conspicuous constellations, are easily within the reach of the pupils of the elementary grades.

Observations are Easily Made.

291. The simplest point at which to begin observation is to watch the shadows about the school building. The younger children will soon see that the patches of sunlight on the floor creep steadily. By putting a tack where the shadow of a window-bar strikes the floor, it will surprise most people to see how rapidly the shadow moves. So soon as children know the points of the compass, they may be asked on what side of the tree at which they are looking the shadow lies, and notice how regularly and steadily

Watching the Sun's Shadow.

it changes its position. When they have realized that the morning shadows lie west of the tree and that they always move around by the north at noon and on towards the east in the afternoon, a new sense of the extent to which law and order enter into the apparent caprice of nature will have been impressed on their minds.

292. Assign to half the pupils the privilege of noting the rising sun and to the other half assign the setting sun. Each pupil must choose a window in his own home, or a definite fence-corner or some clearly marked spot in which he can stand each day and notice either the eastern or the western horizon as the case may be. Now let him draw on paper the horizon line, marking with especial care the position of each tree and house and hill that cuts up into the sky. On the first day of the observation let him come to the spot before sunrise, which in winter at least will be no hardship. Then let him when the sun is half up make a spot on the horizon of his picture and number it one. Lower down on the paper let him mark the date and the hour and the minute at which the sun is rising. A few days later (two or three will be quite enough), let him come once more and mark the place and time of rising as before; and let this be repeated a number of times, indeed as long as the interest can be made to last. At first the pupil will think the slight change is due to his inaccuracy, and this will make him particular in jotting down the point of rising or setting. A very few observations will show him the change is steady and all in one direction. If he continues it over December twenty-first or June twentieth, he will be delighted to see the sun turn back on its course and again seek the east point.

Recording Sun Rise.

293. While this series of individual observations is

in progress, another feature of the sun's movement may claim the attention of the entire class, if the school is in session at twelve o'clock, or if a group of the pupils are about the school grounds at that time. At just twelve o'clock take a small piece of paper, say an inch square, and mark it plainly with the date. Put it exactly on the corner of the shadow of the northeast or the northwest corner of the building, or on the shadow of the end of the flag-pole, and push a good-sized nail firmly through the paper and up to its head in the ground. If the point is on a pavement mark it carefully with chalk. This observation may be repeated every few days for several weeks, when it will be noticed that the shadow grows distinctly shorter day by day from late December to late June, and distinctly longer through the other half of the year. If the experiment is carried through June twentieth or December twenty-first, once more the change in the direction of the motion will be noticed. Carried through the June point, these observations will make it easily seen that the sun, contrary to the general notion, is never overhead in this latitude.

Recording the Noon-point.

294. At this point it will be a pleasant piece of information and observation, that one can always use a watch for a compass on a sunny day. For this purpose an open-faced watch serves best, though a watch with a lid can be used equally well at most hours of the day. At any time when the sun is shining hold the watch horizontally in your hand, letting the sun shine on the face. Now, keeping the face horizontal, revolve the watch until the hour hand points in the direction of the sun. This can be most accurately told by noticing when the shadow of the little, or hour, hand falls directly under the hand and

The Watch a Compass.

not to either side. Just half way between the hour and the twelve of the face is the south point. After the observations on the sun, those on the moon will follow most naturally. These, of course, must consist of referred work to be done out of school hours. The simplest observation will consist in drawing the shape of the moon on every clear night for about two weeks.

Observing the Moon. A little later will come the recording of the position of the moon at sunset. It is in the west, near the sun, when it is young; about on the meridian, or north and south line of the heavens, when it is in first quarter. The full moon rises in the east about when the sun sets in the west. For the older pupils it will be an interesting and beautiful observation to draw the moon and the three or four nearest stars on one evening and then to repeat the drawing the next evening. No other such rapid change of position amongst the stars will be noticed on the part of any heavenly body, excepting in the case of a meteor, or "falling star."

295. The moon is the only heavenly body near enough to have its surface show features distinguishable to the naked eye. If a field-glass or opera-glass can be used,

The Round Moon. it will add greatly to the interest of the observation. One chief advantage will be that the spherical shape of the moon is at once apparent, even when using but a small glass, while to the unaided eye of the untaught observer both sun and moon look as flat as if cut out of card-board. But even the naked eye, aided by the informed mind, can see the markings on the face of the moon. A study of the geography of the moon for a few nights will fix firmly the idea of the moon being a spherical body provided with mountains and plains and revolving in space. It is the one object

lesson to help pupils really conceive of the earth in any clear fashion. The early astronomers who named the markings on the moon called the ridges mountains, and in this later observations prove them to be right. But the flat smooth patches they called seas, and in this they certainly were wrong. We now know there is no standing water on the moon, and possibly no water of any kind. But the old name of seas is so firmly fixed that these patches will possibly always be called seas.

296. For the purpose of fixing these features on the children's minds it will be not inadvisable to carry out the old idea of the man in the moon. When the moon is full, its entire surface may be taken to represent the face of a man, turned so as to bring his left cheek to the front, his nose being turned somewhat to the right of the centre. The nose is formed by the most prominent range of mountains on the moon, known as the Apennines. The right eye is the Sea of Showers and the mouth is made of two seas, the right side the Sea of Storms and the left the Sea of Clouds. The left side of his face is not so gloomily named. The left eye is the Sea of Serenity, the left ear that of Tranquillity and Nectar combined, Tranquillity being above. Just back of and above the ear is the brighest patch on the moon. I do not know what natural feature to liken it to unless we consider the man in the moon to have a prominent bald spot at that point. It is known as the Sea of Crises. Two prominent volcanoes are

The Man in the Moon.

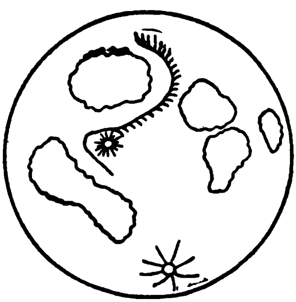

FIG. 49—THE MAN IN THE MOON

apparent to the eye, and if we must adhere to the notion of natural features, these may be pimples, Copernicus on the tip of the nose and Tycho on the lower part of the left cheek, near the chin.

The Proper Spirit.

297. At first sight it may seem absurd and even silly to carry this likeness out to such extremes, but if it is not too soberly done and is handled in proper spirit it will certainly help to fix the features in the children's minds, and they will look for these features with greater eagerness.

The Dipper

298. A knowledge of the few most conspicuous constellations is quite within the reach of the pupil. The most important of these is the Dipper, always visible in the northern heavens, and marked by seven prominent stars, four in the bowl and three in the handle. In February, the month assigned to it in the program to be found later in this work, this group of stars is in the northeast and the handle hangs downward. The two stars in the end of the bowl are known as the pointers and show the direction of the Polar star, the point at which the north pole of the earth if continued would pierce the heavens. The star next to the last in the handle of the Dipper has very close to it another very small star. The Arabs called the two "the horse and his rider," and considered it a test of good eyes to be able to see the rider. Either eyes are better now or the stars brighter, for it is certain that it does not

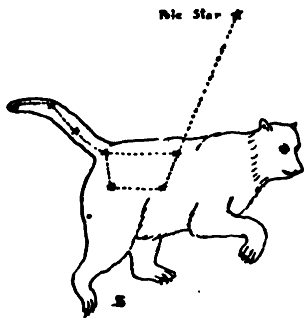

FIG. 50—THE DIPPER AND THE NORTH STAR

take a remarkably keen eye to distinguish the rider. The Dipper is made up of the brightest stars in a large constellation known as the Big Bear and lies in its hind quarter, the handle forming the tail, which is strangely long to belong to a bear.

299. Just across the pole from the Dipper is a group

FIG. 51—THE LADY OF THE CHAIR

FIG. 52—ORION

of five bright stars, forming a rather flattened letter W. This marks the outline of the Lady of the Chair (Cassiopeia). In spring it lies low, while the Dipper is high. In fall evenings, Cassiopeia is high, while the Dipper is low. All the stars apparently revolve about the Polar star.

Cassiopeia.

300. On a bright night in February, well up in the southern sky, will be readily distinguished the most brilliant of all the constellations—Orion, the mighty hunter. One very bright star marks his right shoulder, another his left foot. Less bright but still fine stars mark his left shoulder and right foot. But the three stars in the belt are the most

Orion.

conspicuous feature by which to recognize this beautiful star group. Orion is represented as holding up a lion's skin on his left arm, while in the upper right hand is a club.

301. If his warlike attitude is to have any significance, it must be with reference to the neighboring group in the west, the Bull. In this group a bright

The Bull. star at the eastern tip of a letter V marks the fiery eye of the Bull while the rest of the letter marks the face generally; far past the ends of the V are two stars marking the tips of the horns.

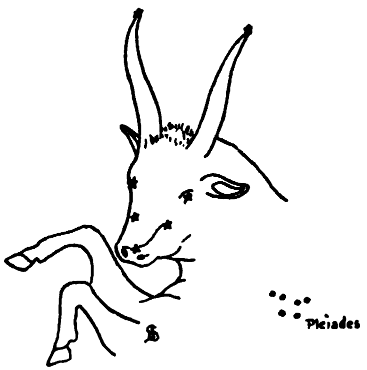

FIG. 53—THE BULL

FIG. 54—THE DOG

In the shoulder of the Bull is the beautiful star group known as the "Seven Sisters," the Pleiades. There are only six, but the story goes that one of them fell in love with a mortal and consequently forfeited her high place.

302. To the east of Orion is a magnificent star, the brighest fixed star in the heavens, Sirius, the Dog Star.

The Dog. The Dog is sitting down; Sirius is in his head, a triangle marks his haunches and two stars toward Orion indicate his hind feet. When the sun in

his course gets around to this constellation, which he does in July, we are said to have "dog days." These are days when popular superstition says boys who go in swimming will be "plagued with boils." Of course if good fresh running water is used, there is no better time for swimming. But stagnant pools get very foul in summer and should be avoided. But the Dog Star has nothing to do with the event. This group of Orion, the Bull, and the Dog should be known to every pupil before his school days are over. They will often serve to lift his mind to higher things.

SECTION III—THE COURSE

XVIII

A COURSE IN NATURE STUDY

303. MOST teachers who are beginning work in nature study will be at a loss to know what subjects had better be treated. With a little experience each teacher, unless his work is definitely laid out by a superior officer, can decide on the subject to present if he will consider carefully a few general principles.

The Subjects to Treat.

304. The first great principle is to use subjects the material for which is sufficiently abundant to make it possible for each child to gain first-hand information by actual observation. This may mean one horse, a dozen apples, or fifty flowers, but the principle is easy of application.

Use Abundant Material.

305. The next point of importance should be that the lesson should be really worth while. That is, that the information gained should be valuable for instruction, for training, or for culture, preferably for all three at once.

Use Material Worth While.

306. The third consideration might well be that such subjects be chosen as fit in well with the other lessons of the week. It may be that this means the materials are well adapted to the work in drawing. Perhaps the reading lesson for the week can be made clearer and more vivid by the observation of the nature material. The reading lesson might be about the forest, when the study of trees would

Fit Lessons to Other Work.

do much to make it vivid. The story of a sugar camp will be made far more interesting if the children can know that the sugar maple is a not uncommon shade tree in most towns, and that they may easily become acquainted with its billowy foliage. If China be the subject, a few tea leaves, first examined dry and then wetted and unrolled, will give a new interest to the familiar beverage.

Associated Topics.

307. Should the geography lesson of that week dwell on the grazing districts of America, what more natural than to study the cow or the sheep, with their strange habits of eating? Should the delta regions be the topic, a few minutes' study of a rill will do more to make the subject clear than could half an hour of talk on the part of the teacher. The meadow, with its dark rich soil and its frequent floodings, will make clear the great plains of the globe, supporting their teeming populations.

Use Topics Suited to the Child.

308. In treating subjects, no matter for what reason they have been selected, careful consideration of the degree of mental advancement of the children must decide what phases of the subject shall be considered. The same object of study may be used in the first grade and the fourth, but the aspect studied would differ almost entirely.

Use Lists With Discretion.

309. In order to assist the inexperienced teacher, and to fill out the gaps in the work of the teacher who has practice enough to decide on most topics, I subjoin a series of subjects. While each subject is assigned to a grade and a definite portion of the year, there is no such rigid sequence as would materially alter the value of many of the subjects if they were used at other times. Where a teacher has but a single grade of pupils to work with and there

is no course prescribed it will be quite possible to make the course as suggested last for four years, adapting the teaching to the grade in question. If the grade be the first, or even the second, some of the topics will be too hard or uninteresting, no matter how treated, and may accordingly be omitted. All of which means that the skilled teacher may profitably take any liberties with the course, which will be accepted in its entirety only by the beginner. No matter what the subject, or what aspect of it is intended to be studied, if the pupil's life touches this subject at any point, this point should by all means be included. In this connection the conscious attempt must always be made to foster a love for animals and kindness to them. But this kindness must always be the product of healthy sympathy and not of maudlin sentimentality.

310. In the course for the first four years of school life which immediately follows, each subject is assigned to a particular season of the year. The points which seem to the author to best repay emphasis are suggested. In each case reference is made by number to the paragraphs of this book in which that subject, or a parallel one, is treated.

FIRST GRADE

FALL TERM

311. The blackbird is a conspicuous bird and makes a good subject with which to waken the interest in these creatures. To stimulate close looking, ask the the color of his eye. Notice his walking instead of hopping, and the peculiar fold of his tail into the shape of a boat when making short flights. Can you tell what they eat? Do they always eat the same things? When do they begin to gather into

The Blackbird.

flocks? Who will report the last blackbird of the season?

312. The golden-rod is an abundant and beautiful plant and will not suffer from free picking. Its yellow color appeals to a wider circle of lovers, both human and animals, than any other color. The helpfulness of the many small flowers in grouping themselves into a cluster (§ 264) is especially to be noticed. How many kinds of insects can be found at one time on one cluster of these flowers? A warm sunny day in early September will give the best answer to this question.

The Golden-rod.

313. At this time caterpillars (§ 113) are very abundant. These, especially the big green kinds, should be gathered and kept in cages (§ 68, 69), being fed daily with fresh tender leaves of the plant on which they were found (§ 116). Each kind should be kept in a separate box. Their hanging up (§ 114) or spinning a cocoon (§ 116) should be carefully noticed. These resting forms can then be removed from the cage and hung up by means of pins in any safe place not too near the heating apparatus. Later in the year the development of these into adult butterflies and moths (§ 114) will excite much interest.

Caterpillars.

314. When the grass is wet with dew notice that it did not rain. For some nights notice the weather and then notice the grass next day. During what sort of nights does dew form most abundantly? Does it form best under trees or on the open lawn? Pin a newspaper down with nails on the open lawn. Does the dew form under the paper? The paper is a blanket, and keeps the heat of the earth from escaping. So do heavy trees, and clouds. If this is used with a higher grade the formation of dew on the outside of a cold tumbler on a warm day will lead them

Dew.

to see that the water comes out of the neighboring air and does not fall.

315. The chestnut burr is a good early subject. Notice its green color when the leaves are green and its brown hue when leaves are brown (§ 285). The prickles that protect from enemies until frost. The brown nuts fall on brown earth. What is the relation of the shape of the nuts to the number and position of the nuts in the burr? What makes the dull mark on the broad end of the chestnut?

The Chestnut Burr.

316. A pet cat, the younger the better, that will submit to examination in the class, will serve better than if the observations were made outside of the class. Notice the padded feet, the claws that can be withdrawn or protruded (§ 192), the whiskers that it hates to have handled (§ 195). Draw attention to its sleepiness because it is a nocturnal animal (§ 193), and its "tired air" of unsociability (§ 191) unless it is still a kitten.

The Cat.

317. The approach of Christmas and the probability that the school-room will be decorated with evergreens, makes these a suitable topic with which to close the work of the fall term. Their leaves are tough to stand the cold. They are slender so snow will not cling too closely and break them down. They often cover the mountain-tops where winds are high, and so the needle shape of the leaves keeps the boughs from being broken or the leaves torn off as often as would be the case if the leaves were broad. On turning back the scale of the cones winged seeds will be found. Why winged?

The Evergreens.

WINTER TERM

318. The lessons on dew will have opened the way to keeping a record of the weather. The new year

offers a good time to begin. For little children this process may well consist of a simple series of marks on a calendar. Take one of the larger calendars with a separate leaf for each month. On clear days, on which the sky is less than one-fourth overcast with clouds, leave the date unmarked. On fair days, on which the sky is more than one-fourth but less than two-thirds overcast, a series of parallel lines may be ruled across the upper half of the date. On cloudy days, when the sky is more than two-thirds overcast, the entire date may be covered with horizontal lines. Rain should be indicated by slanting ruled lines and snow by slanting rows of dots. Such a simple record as this is easy enough for children to keep and proves very interesting.

Weather Records.

319. The bird commonly called the snowbird is the junco. Notice his dark slate coat. What is the color of his bill? What is its shape (§ 168)? What food does he eat? What would happen if he did not eat this food? (He and his winter sparrow friends keep down the weeds most wonderfully.) What is peculiar in the color of his tail? What purpose do these white feathers serve (§ 208)?

The Snowbird.

320. The apple is a fruit of especial interest. The color is green at first and later is bright. What is the advantage of each color? What is the use of the skin? What would happen if the skin were removed? What is the use to the apple of the pulp? Of the core? Of the seeds (§ 280)? A lesson on the varieties of apples is excellent if you can coax in an apple-grower who knows. How does the "worm" get into the apple (§ 128)? What should be done with wormy apples? What should not be done with wormy apples?

The Apple.

321. An examination of the sweet potato will show a large number of marks toward one of the ends. The question as to what these marks may be will bring various answers. The potato may then be set half way into a jar of water, and put in a bright warm place. Here it will sprout, and if strings be given it, soon a beautiful vine will result.

The Sweet Potato.

322. The beautiful group of stars known as the Great Bear can be made out easily in the early evening of January and February. The Dipper is the only important part of it. At this season the bowl of the Dipper is up and the handle down (§ 298), as it hangs in the northeastern sky. Excellent pictures of the constellations will be found in the Century Dictionary, and good ones in a number of similar sources. The *Scientific American* publishes in the first number for each month a chart of the heavens for the month, with much accompanying information.

The Dipper.

323. Every little rill and gutter has more or less sand lying about it. The rock material has been broken up and grains that are harder than the rest remain. In creeks the sand is more or less angular. Sea sand is made up of very evenly rounded grains. For this reason it does not scratch, and some years ago was commonly sold by grocery stores under the name of silver sand, though used only for scouring tinware. If stirred in water it promptly settles. The coarse pieces settle first, the finer later. This process will form layers and make an easy introduction to the study of a piece of sandstone. This, too, will help the children to understand that sandstone was once sand, and was then part of a sea-beach.

Sand and Sandstone.

324. The lesson on dew (§ 314) can almost be duplicated and serve as a lesson on frost, if, in addition

we notice the temperature at least to the extent of seeing whether it is cold or warm. This, of course, follows from the fact that frost is simply frozen dew. What bearing does this have on protecting cultivated plants? **Frost.**

SPRING TERM

325. A good opening for the spring work will be made if the so-called seeds of the sunflower (though technically they are fruits) are planted and watered carefully. When they come up the first pair of leaves should be carefully noticed (§ 220). The plant should be drawn if the pupils are sufficiently advanced. The second pair of leaves will differ from the first, and the third from the second. Notice how the growing plants bend towards the light (§226). Plant a few seeds in well-washed sand, preferably sea-sand, and compare their growth with that of those planted in earth. **The Sunflower.**

326. Cut several twigs from a horse-chestnut tree, and place their cut ends in a jar of water. Notice carefully the position of the buds; the scars where old leaves fell off; the spots in these scars where the sap-vessels passed from the limb to the leaf, one usually for each leaflet in the old leaf; the gummy secretion that covers the buds and keeps out rain that might enter and freeze them. The bigger the twig the longer the leaves will develop out of the nourishment in the twig, but it will rarely happen that the horse-chestnut flowers will develop, the first nourishment in this plant going to leaf. **The Horse-chestnut Tree.**

327. If a stout twig taken from an apple tree be put into water the blossoms will develop as rapidly as the

leaves, usually even a little earlier. Watch the unfolding, by putting the blossoms in a window where the sun will strike them. Examine the blossoms carefully to see whether you can tell what part of the flower is to be the apple. After the petals have dropped off, look again. What part of the flower will be the star on the end of the apple opposite the stem? Can you find the nectar (§ 249)? Is it pleasant to the taste?

The Apple Twig.

328. The robin is most deservedly popular. Interest the children in him by repeated questions that need out-of-door observations for their answer. Do not give more than one or at most two questions at a time. Gradually they will notice the walking and hopping of this bird, and his side motion of the head in hunting worms. Is this latter for listening or for looking? Does he eat anything but worms? When do the robins begin to carry materials for a nest? What do they carry? Where do they get mud? How does the male (Mr. Robin) differ from the female (Mrs. Robin)? Tell them that the male is more prominently marked (§ 175) and get them to tell the real difference. Caution them against trying to look into a bird's nest, as the parents will commonly desert a nest that is much examined. If you want to give yourself a question I believe to be as yet unanswered, try to tell what robins have two white corners on the end of the tail. A later question will be to decide the use of these spots. Ask the children to tell what the robin says. Do not let this be sentimental, but as imitative as possible in sound. If there is appropriateness of meaning, well and good; but first of all attend to the sound, even though the syllables or words used have no meaning.

The Robin.

329. At this time of the year the air will be vocal with the spring songs of toads and of frogs. A visit to almost any standing water or to the quiet beaches of smaller streams will reward one with abundant supplies of the eggs of toads and of frogs. Toad eggs are laid in strings of transparent jelly, and each egg is a black ball. Frog's eggs are in various sized clumps of jelly, the size depending on the species of frog. These masses should be gathered with a considerable quantity of the water, say a quart to each clump, and kept in a bright but not too directly sunny spot in the room. In a short time the tadpoles will quiver in the egg (§ 152) and later work their way out. Notice first the external gills, which soon disappear. Later the legs develop, the hind legs first (§ 152). Toads mature quickly; frogs much more slowly. At first the tadpoles should be fed a leaf of tender lettuce or of water-cress. Later a piece of well-washed meat (§ 158) or of fish food or cracker crumbs will be necessary, as they change completely from vegetable to animal feeders. Toad's Eggs.

330. A few bumble-bees captured at the flowers by entrapping them between an open tumbler and a card will prove most interesting. Notice that some are "white heads," that is, they have a square white patch in the front of the face. These are males, and cannot sting (§ 106). Hence they can be, and should be, handled freely. Care must be taken not to squeeze them. If this is well done, it will be an excellent lesson. It helps children to overcome senseless fears; but best of all, if we handle them with genuine care, it teaches kindness to dumb creatures. The great objection to cruelty is not because it hurts the animal but because it demoralizes the children. The Bumble-bee.

Notice how the tongue is folded back on the breast when not in use, and how it is turned forward to probe a flower (§ 92). They gather the nectar of flowers and make it into honey. It is too early yet to say more than that the visits of bees help the flowers to produce seeds.

331. Call attention to the shadow of the vertical edge of the window or of the upright window-bar, marking the position on the floor at nine o'clock and again at ten, eleven, and twelve. See how nearly the shadow comes to the same place at the same hour the next day, and the next week. A sun-dial in the yard is most interesting if it can be constructed. Nothing will make clearer the fact that the earth does not move uniformly about the sun than the steadily varying difference between the sun-dial and the clock.

The Sun's Apparent Daily Motion.

SECOND GRADE

FALL TERM

332. The fall behavior of the crow is most interesting and makes him well worth watching. Does he walk or hop? Does he soar, or coast, or flutter constantly when he flies? On what does he feed? Does he fly with a company of his fellows in flocks? Which way do the flocks fly in the early morning? In the late afternoon? How many flocks can you see in one late afternoon? If you can put older pupils at it, get them to see how many birds there are in each flock. A good way to get the number of animals in a flock, or of people in a crowd, is the following: starting at one end, count ten, then by judgment jump to twenty, then to forty, to eighty, and so on. A little practice will enable one to estimate by this method with very fair accuracy.

The Crow.

333. There will be little difficulty in getting some boy who loves to roam the woods and meadows to bring in a turtle. Give him his appropriate surroundings (§ 69). Try him with three or four different kinds of food. Try an apple, a turnip, a piece of meat, and a lump of sugar. Can he see? Can he close his eyes? Does he close them both at once? Can he hear? How many toes has he? What are they good for? If you can find an old and empty turtle-shell look at the inside of it and see whether you can tell of what bones the shell is made (§ 156).

The Turtle.

334. If the school be located in a town it will be easy in fall to get a cosmos flower. If the school be in the country the sunflower will serve the same purpose. Show how this, like the golden-rod and the dandelion, is a cluster of flowers belonging to the great composite family. Notice the gay flowers on the outside, with their broad attractive corollas. These serve to draw the insects to the cluster. On the rounded part of the cluster are many little flowers. First the outermost ones bloom. After these the next circle. Can you tell in your specimen which circle of flowers is blooming? How can you tell? Why does a sunflower or a cosmos last so long?

The Cosmos or the Sunflower.

335. The peanut is an interesting fruit. It cracks down both sides like a bean or pea. It has usually two or three seeds on the inside of it. Each seed can split in two, like a bean. When it is split you will find the baby plant as a little peg lying between the two sections. The sections are the food for the plantlet to grow from when the peanut is planted. Is it good for us? Why is it not wrong for us to eat a baby plant and its inheritance of nourishment?

The Peanut.

336. On some day three or four days after the almanac

announces a new moon and the evening promises to be clear, ask the children to carefully draw the moon as they see it in the west soon after sunset. In three days try it again; and so on every three or four days for two weeks. Then take a ball. Ink one side of it to represent the side away from the sun and chalk the other half to represent the sunny side of the moon. Then slowly turn the ball before them until they realize that at first we only see a little of the sunny side of the moon. Then we see more and more until at full moon we see the entire sunny half of the moon. There are two peculiar features that may attract the children's notice. When the moon is just beginning to show its thin line of light after new moon (commonly called the dark of the moon) it is often faintly lighted over all the rest of the circle. When this is true, it is because the bright part is lighted by the sun, and the faint part is illuminated from the earth. The moon then has full earth, just as two weeks later we have full moon. The earth looks as bright and shining from the moon as the moon looks from the earth, only the earth looks very much larger. The other peculiar feature is that the bright part will look too big for the dull part. This is because anything very bright looks bigger than when it is dull. In our glass electric-light bulbs the filament looks as thick as a knitting-needle when it is lighted but when it is dull we see that it is very thin indeed. This is not due to expansion on heating. It is solely an illusion due to the brightness of the filament.

The Moon's Change of Shape.

337. The approach of Christmas once more makes the evergreens suitable subjects. Choose for the present lesson the holly or the laurel, depending on the locality. The one which is most easily obtained is naturally the

better subject. Holly is the more interesting of the two; perhaps, chiefly on account of its attractive berries. How do these plants differ at this season from most plants? How are the leaves adapted to this work of resisting color? What temptation does this offer to browsing animals? How does the holly protect itself? How does laurel (§ 243)? (Laurel is sometimes called "lambkill.") Why are the holly berries bright (§ 281)? What is inside of them? The Holly or the Laurel.

WINTER TERM

338. Whether the dog (§ 187–191) shall be studied collectively by all the pupils under the direction of the teacher in the school-room, or by referred questions at home, depends on many circumstances, mainly however on the tact of the teacher and the extent to which he enjoys the confidence of the patrons. If the work is referred work, ask the children first to draw the dog from side view, particularly noticing the hind leg. When they report, ask questions. How many toes on the hind feet? Where is his heel? His knee? His hip? How many toes has he on the front foot? How many of them are useful (§ 187)? How many are useless? What may eventually happen to the useless one? What has happened to one toe on the hind foot? Where is his wrist? Where is his elbow? His shoulder? How many nipping teeth (incisors) has he? How many tearing teeth (canines)? How many grinders, (premolars and molars)? His molars cut meat much like a pair of scissors cuts it, rather than grind as molars usually do. The earlier account of the dog (§ 187–191) has suggested material available here. The Dog.

339. It is interesting to realize that our winters are not birdless. If there are trees about the school the

downy woodpecker is very likely to visit them. If a piece of firm beef suet be nailed up in a tree the likelihood can be changed to a certainty. He is a bird of about the size of a sparrow, but instead of perching on the limbs he stands upright against the trunk. He braces himself by means of the feathers of the tail. His crisp "tweet, tweet," in a busy undertone while he industriously scours the bark for insects and larvæ and spiders, together with his light chopping taps on the bark, will call attention to him. He is striped black and white, and the male has a little touch of red on the nape of the neck that the female lacks. Under the same surroundings the nuthatch (§ 361) and the chickadee (§ 384) may be noticed but easily discriminated.

The Downy Woodpecker.

340. If the circumstances make the downy inaccessible, the chicken may serve at this time. Notice the stout legs for constant running and scratching; notice also the short poor wings. It is probably because the flight is so poor that the meat of the breast, which works the wings, is white and tender. The eggs are big (§ 183) so the chicks can grow big enough in the egg to run as soon as they come out. The rooster defends and cares for a bunch of hens. So he must be beautiful to charm them (§ 177) and have strength to drive away other roosters (§ 177). What do they get when they scratch? Scratch for a while, yourself, and see. Try them with the various things you find.

The Chicken.

341. If there is an old board fence about, examine the under side of the running rail for the winter resting stage (§ 114) of our butterflies. Some of them will hang head down, being fastened by their tails. Others will be buried in masses of hair which they

shed when they threw away their last caterpillar skin. If the fence is near a patch in which parsley or parsnips or either cultivated or wild carrot has been growing, one is very likely to find the chrysalis of the swallow-tailed butterfly. This is fastened by the tail, but the fine pointed head is held up by a strap of silk about the shoulders. The chrysalis should be handled just enough to make it wriggle and thus prove itself alive. Much handling kills it. If the creature be pinned up in the room against a board by its own strap it will doubtless transform later in the winter or in early spring into the butterfly.

The Chrysalis of the Butterfly.

342. If boughs of two evergreens, one of them any pine, and the other any spruce or hemlock, can be found, they will make effective decorations and good material for lessons. The previous lesson on evergreen (§ 317) can be reviewed. The tough leaves are hardier than the tender leaves of maple and elm that must be thrown away before winter comes. The sap has a sticky resin with it that probably keeps it from freezing so readily. The needles are narrow and shed the snow more readily than broad leaves would. The first lessons in discriminating evergreens can come here. The needles of the pines are in bundles, wrapped together at the bottom. Our commonest pine, the white pine, has five needles to the bundle. In the spruces, firs, and hemlocks, the needles are separate.

Pine, Spruce and Hemlock.

343. The orange is now so common as to be quite available for this work. Its golden color is attractive (§ 279). Its oil in the skin protects against moulds and insects. The pulp attracts animals (§ 280) who eat it but discard the bitter seeds (§ 284). Notice the little spots in the stem end, count them,

The Orange.

and later count the segments (each a pistil). What is the meaning of the spots in the stem scar? Find in any good mythology the story of Hercules and how he went to the Islands of the Hesperides for the "golden apples," which were undoubtedly oranges.

The Constellation Orion.

344. After the Dipper in the Great Bear, no group of stars is more commonly known than Orion, the most beautiful of all the constellations. During the early evening this group of stars will be found to the southeast of the zenith in January, nearer the south in February, bearing towards the southwest in March. The mark by which it can always be recognized will be the line of three bright stars which are supposed to form the belt of Orion. A very bright star forms his right shoulder and another his left foot. The Century Dictionary contains an excellent picture of this constellation. A mythology, if available, will give you a story that can easily be made interesting.

Pebbles and Pudding Stone.

345. Whenever small stones are rolled in the bed of a stream or on the beach of a lake or of the sea, the corners are rubbed off by friction with each other. In mountain streams and meadow brooks often only the rougher angles are smoothed off. When the process has gone on long enough the softer stones are worn completely to sand or even to fine mud. But the harder stones roll and roll, and grind and rub, until they are far more nearly spherical. Such stones if small are known as pebbles, if large as cobble stones. If in the neighborhood there is any of the rock formation known as pudding stone, or conglomerate, it will be well to show a piece of it to the pupils and tell them that originally that rock was a sloping beach where pebbles and mud were piled to-

gether. Later the mud hardened as more material was piled on top of it, and baked by the inner heat of the earth, and so changed into pudding stone.

346. Melt a piece of ice slowly in a tin-cup over a small lamp. If any of the children are old enough to read a thermometer, stir the water steadily with a thermometer, and notice that while the ice is melting the water gets no hotter, or very little. This shows that all the heat is going to the melting of the ice. When the ice is all melted the water rapidly gets warmer. If the thermometer reads high enough keep this up until the water gets to the boiling point. Now again the water gets no warmer. All the heat now goes to changing the water to steam. So steam, water, and ice are all the same material, but with more or less heat packed away with them. What is the temperature of melting ice? Of boiling water? When does the water get uncomfortably hot to the hand? The temperature of the blood is ninety-eight and a-half.

Ice, Water and Steam.

SPRING TERM

347. The violets have as much charm for the children as almost any of the flowers. At first sight it would seem almost wrong for children to pluck such handfuls of flowers as they do of violets. But no plant can spare its flowers better, because it has another set of unattractive flowers near the ground and these really set most of the seed. The blue of the violet is particularly a bee color (§ 263). Even big bumble-bees visit the violets, and when they alight on the flower they drag it to the ground. A light spot in the middle of the violet tells the bee the location of the honey, and dark lines show him just the direction his tongue must take to reach the nectar. This is in the

The Violet.

little sac or spur at the back of the flower. Almost half way up the side of the stem that holds the violet are two little teeth. These, in the ancestors of the violet, were once leaves, but they were discarded probably so as to give the flowers a better chance. If one will dig up a violet plant in late May or early June, he will find small flowers that look like buds very close to the roots. They have no corollas, and never open until they have fertilized themselves, set their own seed and ripened the seed ready to scatter. We call such flowers secret or cleistogamous flowers.

348. Review the fall lessons on the peanut (§ 335), especially noticing the two parts of each kernel and the peg between them. Now plant at least a dozen such kernels in earth and keep them in a sunny spot, and water them enough to keep the ground from drying out. Dig one up in three days, another in five days. Then wait for the appearance of the rest. Study them every few days. Notice what happens to each part of the seed.

The Growing Peanut.

349. The beech tree has unusually beautiful long buds, with dainty papery bud-scales. Cut twigs of the beech and draw them. Consult the lessons on the horse-chestnut twig (§ 326) for desirable points. Put branches in water and allow them to unfold their buds. Study and draw them often. Notice particularly the dainty folding of the beech leaves in the bud and their gradual unfolding. If beech is not available use elm, but beech is much prettier. Birch twigs will answer very nicely, too.

Bursting Buds.

350. The catbird is one of our common birds whose acquaintance well repays cultivation. Notice that the color is not uniformly gray as one at first supposes. After the darker wings and tail and

The Catbird.

the crown, especially of the male (§ 175) have been noted, ask where the patch of chestnut color is found. In what sort of surroundings does the catbird live? How is his tail adapted to his life (§ 162)? Do not finish the study of the catbird until the pupils realize that the simple cat-like call is only a scold note, and that this beautiful bird is one of our most exquisite singers. It is one of the few birds that imitates other birds about it. Indeed, it is a first cousin of the southern mocking-bird.

351. Over pools or near streams in the meadows the swift darting dragon-fly always attracts attention. Let one of the older pupils catch one in an insect net. Put it into a box with a little cotton so that it cannot batter itself to pieces before the lesson is held. Handle it fearlessly. It cannot sting (§ 106) and its jaws are usually too small even to catch hold of the flesh and are never strong enough to give any objectionable pinch, much less to do harm. The gauzy lace-work of the wings is remarkable. The large compound eyes make up nearly the whole head, and the separate facets are large enough to be visible to the naked eye, and easily seen under a hand lens. Then look between the compound eyes and you will find the three simple eyes. The colors of the dragon-fly are often of that most beautiful of all kinds of colors, the iridescent colors. These depend not on coloring matter but on surface structure, and vary with every change in the angle of the light. What do dragon-flies eat? Do they "sew up the ears of little children that tell lies"? Are they "snake feeders," or "snake doctors"?

The Dragon-fly.

352. A slight acquaintance with the clouds may well begin at this early age. The sky with its countless cloud modifications is so beautiful that it is a pity it is not more

frequently watched. There are four main types of clouds, which the children can easily recognize. The "fleecy" clouds (cirrus) are light and transparent, with melting edges. These clouds are usually about five miles above the surface, and are made of snowflakes. The "woolpack" clouds are thick, white, piled-up clouds, with rolled edges. They look like the great masses of steam that roll back from a locomotive. They are particularly fine of a hot summer afternoon. It is these clouds one can usually imagine as forming "pictures." Woolpack clouds are usually about two miles above the ground. A third kind of cloud are the straight clouds (stratus). These run in long lines and sheets, and are best seen near the horizon at sunrise and sunset. These are low clouds, often within half a mile of the earth. The "storm cloud" (nimbus) is a dark cloud, usually with ragged edges from which rain or snow falls or will shortly fall. There may be all kinds of combinations of these clouds. Young people had better talk of them as mixed clouds than to try to add new terms at this stage of their progress. For instance, they had better talk of a mixed woolpack and straight cloud than of a cumulo-stratus.

The Clouds.

THIRD GRADE

FALL TERM

353. I fear the reputation of being English will always attach to our common sparrow, though he is equally German and French. His better name is house-sparrow. All bird men seem agreed that he is a pestiferous fellow without a redeeming quality. But he is here to stay, and we had better make the best of him. One of the good uses he may be to the

The English Sparrow.

school child is to make him observant in the matter of birds. Can you tell the male from the female? The male has the greater color contrasts (§ 175). Just where are they? What is the shape of his bill? What other bird do you know with such a shaped bill? What do birds with such bills eat? Do sparrows walk or hop? Do they soar or hover or always flutter? What do sparrows use in building their nests? This is a matter of recollection, of course at this season, unless there are old sparrow-nests about, when it will be a matter of much interest to take one apart and see the miscellany here thrown together. Notice that the house-sparrows gather together into flocks in the fall as if to migrate (§ 184), and then they do not go. Perhaps it is a relic of an old habit, and that long ago they used to migrate.

354. In the country the toadflax, sometimes called "butter and eggs," grows by every road-side, while the nasturtium will give much the same lessons for the city pupil. The flower cluster coöperates in calling the notice of the insect (§ 261). The light yellow of each corolla calls attention to the individual flower. The orange lip tells a heavy insect where to alight. When he does so the mouth of this snap-dragon flower opens, as it would not to a light insect. When the bumble-bee sits on the lip, it opens and discloses two rows of yellow hairs between which he pushes his tongue. These guide him down into the spur or honey-sac. Above his head, against the upper lip of the flower are the stamens with pollen, and between them the sticky head of the pistil. The pollen, if ripe in this flower, will dust on his head. The pistil, if ripe and sticky, will pick off pollen that he caught on his head at the last toadflax he visited. This will make the ovary at the bottom of the pistil swell

Toadflax and Nasturtium.

up with seeds. By looking at flowers farther down in the cluster, or on neighboring plants, all stages of development up to the dry pod, ready to scatter its seed, will be found. The nasturtium has been sufficiently closely described in an earlier section (§ 249).

355. The introduction of the aquarium into the school will be an event. Use if possible a rectangular aquarium (§ 58); a home-made one will answer well.

The Fish.

A common minnow or sunfish or, indeed, any small fish from the stream will be better than a goldfish (§ 61–63). Study particularly his movements, noticing what fins he uses. A general account of this study (§ 60–67), and of the feeding of the fish and the care of the aquarium, will be found earlier in the book.

356. In the study of the pear the teacher can be guided by the directions given under the study of the apple (§ 371), remembering of course that the pupils are

The Pear.

older and can see farther into the subject and get reasons more thoroughly. At the close of the lessons get them to realize the great similarity between the pear, the apple, and the quince, and tell them these fruits are close cousins of each other, while the peaches, plums and cherries are close cousins of each other but more distant cousins of the pears. All of these, with the strawberries and blackberries, the hawthorn and many others, belong to the very important rose family.

357. At least the older pupils may now learn to read the thermometer. Notice two consecutive numbers on the thermometer, say 70 and 75. See how many strokes

The Temperature.

lie between them. If five, their reading is easy. If the two consecutive numbers are 70 and 80 and there are five divisions, then of course each division counts two. Seventy-three, for instance, will

lie one and a-half spaces above seventy. It ought to be possible to read such a thermometer to half a degree, though with young pupils this is not necessary. To read accurately, the eye should be just level with the top of the mercury in the tube. Try the temperature in the room at the level of the head. Stand the thermometer on the floor and read it again. Hang it up before the register and read again. Try it outside in the sun, and again in the shade. Let it hang at least five minutes in each situation before reading it. When the pupils can read the thermometer well, hang one outside a window where it can be read without opening the window and without the sun falling on it. A north window is preferable. Then at noon each day (or any other definite hour) take the temperature and record it on the monthly calendar. After one whole month of records, put in some permanent place a record of the highest temperature during the month, at noon, with its date, also the lowest, with its date, and the average for the month.

358. The approach of Christmas, especially in the cities, will bring mistletoe into the market and make it a good subject for study. Try to get a fair-sized piece that will show the section of limb on which the mistletoe grows, for the mistletoe is a parasite and grows on other trees. From Virginia southward the host is usually a live oak, though often a sour gum tree. In southern Pennsylvania, New Jersey, and Delaware, the sour gum is, so far as my experience goes, the almost invariable host. North of this it is not found. It is easy to tell where the mistletoe begins and the gum ends. This plant draws a large part of its nourishment from the plant on which it lives; so its leaves are pale. But when the leaves drop from the

The Mistletoe.

other tree the mistletoe still keeps its own leaves and works feebly. The white berries are bird-eaten (§ 283), but the seeds inside of them are so sticky that they cling to the bill of the bird, who wipes them from his bill upon the limbs. Here they sprout. Our English ancestors, before they were converted to Christianity, had a Yuletide feast that came at the time of the shortest day. They thought the mistletoe holy, and used it in their religious celebrations. When they became Christians the use of the mistletoe got transferred and it continued to be used in the celebration of Christmas, though as a home, not a church celebration.

WINTER TERM

The Cow or the Rabbit.

359. In the country where the children come in contact with cows outside of school hours the cow will be an excellent subject for a lesson. In the city, where the cow is out of the question, it may be possible to get a tame white rabbit, which can be kept for a few days in the school-room, and may interest. The cow's toes make a good starting point. How many toes has she on each foot? How many of them are of use (§ 199)? (How do the others come to be there?) What sort of teeth does she have in the front of her upper jaw (§ 200)? Does a cow chew grass when she nips it off? If not, when does she chew it (§ 201)? Can you see the cud come up the neck? If accessible a piece of tripe from the paunch and one from the honeycomb will be of much interest. When a cow gets up, on which feet does she rise first? (How is this with the horse?) Why does the cow give milk (§ 198)? How long after her calf is born will the cow give milk? How much milk will she give? How much butter is in that milk? These last three questions are referred to parents

who are careful dairymen. If the rabbit is chosen, notice the long ears. Why are they so long? Why need the rabbit hear well? What does the rabbit like best to eat (§ 208)? Try three or four kinds of food. How does the rabbit's jaw work when he chews? How does the rabbit show that he is angry? Do not anger him purposely. He stamps his hind feet with a vigorous patter whenever he becomes excited. Look at his front teeth. What other animal has teeth like these? To what group of animals does the rabbit belong (gnawing animals or rodents)? What other animals are in the same group (§ 203-§ 209)?

360. Either of the low evergreens known as arbor vitæ or box will serve. The previous lessons on evergreens will serve (§ 317) as a model, with the added feature that these are used for borders and gardens because they grow very slowly. The Japanese take plants like arbor vitæ and keep rubbing off the tips of the leaves with their fingers. This makes the plants grow very slowly, and look like miniature trees. The poor Jap who owns only a few feet of garden will make it look like a distant big lawn by putting dwarf trees and little bridges and waterfalls in it. Sometimes a little evergreen tree, not over two feet high, and growing in a pot not over ten inches in diameter, will be more than a hundred years old, and be an heirloom in the family.

Arbor Vitæ or Box.

361. The lesson on the downy woodpecker (§ 339) will give the idea for a lesson on the nuthatch. This bird does not peck with a sharp blow like downy, though it does tap a little. But the careless way it runs down the tree trunk, with its head pointing down, and out the under side of the limbs, will serve to easily distinguish him from a woodpecker,

The Nuthatch.

who always stays head up. The nuthatch is slenderer than the very chunky and black-headed chickadee, and keeps more to the trunk and heavier limbs, while the chickadee works more amongst the twigs. The nuthatch calls "yank," "yank," as he works. Where will he be in the summer-time (§ 384)?

362. On the tips of the branches of shrubs and trees, especially of cultivated evergreens, it is very easy at this time of the year to find the cocoons of the bagworm. They are about an inch and a-half long, tapering at both ends, and have small fragments of sticks fastened to the sides. Inside of this case, at this time of the year, we find the brown pupa, if the cocoon was that of a female, and the cocoon is empty if it was that of a male. The mother's body is dry and brittle, and easily breaks open. When so broken it is seen that she died with her eggs inside her body. These hatch in the spring and creep about as small caterpillars that keep their tails in a small bag which they carry about with them. As they grow they enlarge the sack to fit their new size. This continues until the larva is full grown, when the bag is permanently fastened up. The male soon emerges from the bag, a small moth with wings. He visits the female in her case, she not getting wings and never leaving the case. Her eggs mature inside her body and are never laid; the young, as mentioned, escaping from her dead and dried body the following year. Often the cases contain the cocoons of parasites, known as ichneumon-flies (§ 126). The eggs were laid in the body of the caterpillar by a small wasp-like insect. A very interesting story is said to attach to this creature in India. The Hindoos believe that if a man has led a sinful life he must pay for it by having his soul go into the body of

The Bag-worm.

a lower animal when he dies. If he was a glutton during life, his soul might enter a pig; if he was brutal, he might be a tiger in the next life. His soul thus went from body to body until it was perfect, when it entered into its final rest. The poor of India have much difficulty in getting enough wood to build their fires for cooking their food, and there is a bitter temptation to steal firewood. These Hindoos believe this bag-worm has in it the soul of a man who in his lifetime stole firewood, and is now serving a sentence by carrying sticks.

363. The hickory nut is a splendid subject to show how well nature takes care of some of her babies. While the young nut is forming there is a thick tough case on the outside of it, which defies the attempts of most animals to get at the growing kernel. When the nut is about ripe and the hull cracks open with the frost, the shell of the hickory nut itself is an even better protection than was the old hull. In many hickory nuts the protection goes even farther and the kernel itself is bitter. Fortunately for us, many hickory nuts have not yet learned this wise trick.

The Hickory Nut.

364. A little to the west of the point overhead, in the early evening at this time of the year, is seen the finest star cluster in the heavens. Occasionally this small group is called the Little Dipper, though it should not be so called. A better name would be the Seven Sisters. It will, of course, be noticed that there are really only six stars. The story runs that the Seven Sisters were pursued by Orion. They begged Jupiter to save them and he turned them into pigeons, and they flew up into the heavens, where Orion still follows them, being just to the east of them. When the Greeks attacked the city of Troy, one of the Seven Sisters was so much interested in the city that she

The Pleiades.

could not bear to see it destroyed and left the heavens, to join her lover. So there are now only six stars.

365. A few experiments with the pendulum are very easily conducted and serve to give the pupils an idea of the method by which experiments are made. Take a ball of wood, or a big glass marble, and attach a string to it. If it is a wooden ball, a tack will serve; if the ball be glass, cement a small metallic button with an eye at the back of it to the ball, and tie the string to this. Hang the string to a gas-fixture, or in a doorway, and count the number of swings in a minute. It will be very easy to prove that a long pendulum swings less frequently than a shorter one. More surprising is it that the same pendulum swings as often per minute whether it takes a short or a long swing. If a pendulum with a wooden ball, and one with a glass ball, are made of the same length, both of them will swing the same number of times per minute. The strings should be made at least forty inches long to work well under the conditions of such a simple experiment. The length of such a pendulum must be measured from the point from which the string hangs to a point a little below the centre of the ball. It will be found that if this distance is a little less than forty inches the pendulum will swing once a second, or sixty times a minute.

The Pendulum.

366. Limestone is one of our few stones that is soft enough to be easily scratched with a knife, and in that respect is different from the great majority of rocks. If a little limestone be pounded very fine and then put into a little strong vinegar that is being heated in a tin-cup over a lamp, the powder will slowly bubble up and dissolve. This happens very slowly in rain-water even, and so practically

Limestone and Marble.

all our spring and river water has at least a little lime dissolved in it. It is in this way that plants get the lime they need from water, and from these plants the animals get the lime needed for their bones. When limestone has been very heavily baked by the interior heat of the earth, it is changed into marble.

SPRING TERM

367. It will be found a very interesting experiment to take a saucer and fold a piece of flannel so that it will be two or three ply and will lie completely in the saucer. Now moisten the flannel, but do not let it stand in water. On this flannel lay cloverseed and cover it with a similar piece of moist flannel, and then with another saucer. Stand this in an out-of-the-way place and examine it every day, drawing a few of the seeds each day. Other cloverseed may be planted in a pot at the same time, and this will serve to show later stages of the growth, as the clover will not grow very far in damp flannel. An interesting seed test can here be made. Get each of several children to bring cloverseed from home if possible, or purchase from several dealers. Shake up a little seed, say a teaspoonful, and spread it on the desk. Count out the first two hundred seeds you come to and see how many of them are clover and how many are other plants, probably weeds. (What per cent. is this?) Now out of the cloverseeds, not taking the weeds, count one hundred seeds and plant them in flannel. What proportion of these (what per cent.) grow nicely? What proportion grow poorly? What proportion do not sprout? Which of the samples of cloverseed is the best?

Clover Seed.

368. The dandelion is the best single flower from which to teach the nature-study side of plant life. The rosette

of leaves saves the space for the whole winter, so that the plant has its own little area reserved for next year. It grows a little any warm week of the year. Its teeth on the leaves, as the leaves grow, push the blades of grass aside so that the plant can get abundant light (§ 235). The leaves are bitter, so as to keep animals from eating it (§ 243), though here, as usual, man steps in and does the prohibited act (§ 243). The flowers grow in great clusters of two hundred or so in a single prosperous head. They open only on sunny days, when insects are about (§ 272). They are yellow, a color to which all kinds of insects are susceptible (§ 249). They open only by daylight and close each night. When the grass is short the dandelion stems are short, but when the grass grows the dandelion stems grow, too, and keep above the grass. When the heads have opened up day after day and all the flowers have been visited by the insects, they close up and stay shut until all the seeds are ripe. Then, when a good day for planting dandelions comes, the heads open up for the last time and uncover a great globe of seeds, with white hairs, which break away and float on the wind to every quarter of the country. There is not a single month of the year in which dandelions do not bloom, if the plants grow on the sunny side of sheltering walls.

The Dandelion.

369. Our different maple trees bloom through a long period of spring. It will be most interesting to catch the succession of them, beginning with the inconspicuous blossoms of the silver maples and going through the more sightly red and the showy Norway to the latest and most graceful of them all, our stately sugar maple. To watch the trees through one spring will be a revelation to most people, who cannot realize

Maple Buds.

that any but a few trees bear flowers. Of course, all of them do; and to come to see the flowers adds very much to one's interest in trees. Not only should the twigs be forced in water in the school-room, but the pupils should be guided to see them on the grounds, along the streets, and in the woods.

370. Few spring trees are more beautiful in their blossoming than the peaches. The stems are short, so that the flowers hug the branch, because there are no leaves to hide the blossoms. The great wealth of stamens with their yellow pollen and the nectar in the bottom of the flower draw the bees. A very little inspection, especially if one cut the blossom in two, will show the little part that is to be the fruit. The almond is a first cousin of the peach, and in blossom looks very much like it. The Japanese are perhaps, as a nation, the greatest flower lovers in the world. When the season of almond blossoms comes they have great out-door festivals to enjoy the wondrous beauty of these blooming trees.

Peach Blossoms.

371. If the teacher has a quick ear and wants to start his pupils in the delightful habit of listening to bird notes, the song sparrow offers a charming opportunity. This little bird is about the size and shape of the house (so called English) sparrow. It is not, however, so highly colored, but is more streaked, especially on the breast. The characteristic mark is that a number of the streaks of color on the throat rather merge, giving the effect of a triangular necktie. The song of this bird starts with a single note repeated three times, followed by a trill. If bird-notes seem beyond the reach of teacher or pupils, the meadow-lark (§ 180) will serve as a more than commonly interesting subject. This striped bird,

The Meadow-lark or the Song Sparrow.

about as large as a blackbird, will be found walking on the ground. When frightened he flies in a straight course, with much fluttering of the wings, about six or eight feet from the ground. As he flies he "shows the white feather" (§ 208). His song is a very cheerful whistle, long drawn out. One of my pupils thinks he says, "Can't see me-e-e!"

372. The wasps are now busy making their nests. A little search under the eaves of the wood-shed or under the roof of a covered porch or in a garret will disclose either a paper or a mud nest. The paper is made of wood fibres chewed off from dead limbs or weather-beaten boards. The mud is taken from some puddle. Very often it is possible to follow the wasp to the spot from which she is gathering her material. You will lose her often, but as she usually follows the same path time after time it is not difficult to pick her up again. In the mud cases the wasp makes she usually stores spiders, and lays an egg in each compartment. When the young wasp larva comes from the egg it feeds on the spiders. In the paper cases, the young have no stored food but are fed directly by the mother or one of the helpers. They eat nectar from flowers, pulp of sweet fruits, and later crushed flies and other insects.

The Wasps.

373. A more than commonly interesting lesson may be made from a study of the foods commonly eaten at the table. This work correlates especially well with the geography lessons. It may be well to take a typical breakfast. The opening dish may be prunes or an orange. The prunes are doubtless from California and their sweet meat was provided by the tree so as to secure the transportation of the seed (§ 279), whose hard stone prevents

The Breakfast Table.

its being eaten (§ 280). In case of the orange, probably from Florida, Jamaica or California (the fruit dealer knows in each case); the rind keeps off insects. The pulp is pay to the larger animal for carrying the seeds, while the bitter taste keeps the seeds from being eaten (§ 284). A dish of oatmeal or shredded wheat may follow. The oatmeal probably grew in the upper Mississippi Valley and was milled in the East. The wheat grew in the northern tier of states or in Canada, and was shredded at Niagara by electric power generated from the water-power of the falls. A piece of steak probably ranged just east of the Rockies and was killed in Chicago. The potatoes were doubtless a home product. The bread was probably grown in the North, milled in Minneapolis, and perhaps baked in the nearest large city. The coffee (if coffee there were) came doubtless from Rio Janeiro, even though the label called it Java or Mocha. The sugar probably grew in Hawaii or the West Indies, and was purified in New York or Philadelphia. The above heavy meal embraces much so as to cover more cases. Few children will have had so much, fewer still have needed it.

The Sun's Yearly Movement.

374. The pupils have already noticed that the sun's shadow travels about an object from the west through the south to the east. It remains to notice the yearly movement. An earlier section (§ 292) gave full directions for noticing the points and times at which the sun rises and sets. It will suffice here to add an observation to be made by the whole school. Drive a straight stick into the ground so that it shall be exactly vertical. Try it with a plumb-line made from a thread and a heavy metallic button. Each day, exactly at noon, measure the length of the shadow. It will be found to grow shorter up to June

twenty-first and then to lengthen. An enterprising teacher may care to make the following experiment: Take a stick of some definite length, say that five feet of it sticks above the ground. Now at noon on March twenty-first, when the sun is shining vertically on the equator, measure the length of the shadow. Suppose it to be four feet. Now draw on paper a right-angled triangle. Make one side about the right angle as many inches long as the stick is feet high. The other side of the right angle should be as many inches long as the shadow is feet long. Now draw in the third side of the triangle. With a protractor measure the angle at what represents the tip of the stick, and this will give you the approximate latitude. If this be done on June twenty-first, when the sun is shining on the Tropic of Cancer, twenty-three and one-half degrees above the equator, you can perform the experiment in just the same way at this date, but when you have measured the angle you must add twenty-three and one-half to the size of the angle to get the latitude.

The Daisy.

375. The daisy is a great favorite of the children. It is one of the plants in which the individual flowers are very small and they cluster in coöperative communities. The little yellow flowers so abundant in the centre furnish all the pollen (§ 254) and set most of the seeds (§ 255). But the outermost row have elongated white corollas, and give themselves chiefly to the work of attracting the insects (§ 334). The bitter and tough character of the stem makes it distasteful to browsing animals, while the large number of seeds to the head insure many successors in the immediate neighborhood next year. One new daisy may thus next year start an entire clump.

FOURTH GRADE

FALL TERM

376. When the blue-jay is abundant he is a great favorite with the children. His virtues are conspicuous. He is gay of plumage, bold and inquisitive, and his voice keeps one constantly aware of his presence. What does he eat? How long does he stay? How do other birds like him? What is his flight? Does he walk or hop? In what sort of locality is he found? These and many other questions will be fruitful. If the blue-jay is not available, the pigeon is very interesting, chiefly as we trace in him signs of his ancestry. He sits on roofs, not on trees, because his ancestor was a rock pigeon in western Asia. He eats chiefly grain, and when he has young he feeds them food he himself has at least half digested, putting his bill into the throat of his young. In spite of all the variations man has bred into this bird, common pigeons often revert,—that is, turn back to the old blue type, with shiny neck, and two black bars across each wing.

The Blue-jay or the Pigeon.

377. The wonderful daisy family forms a large part of the fall flowers. A sunflower will show the type well (§ 334). On the central disk are flowers whose corollas are tubular. About the edge are flowers with long yellow, strap-shaped corollas. Now the plants of this family can be arranged by the children into three groups, and the arrangements will test their observation and in a few cases the eyesight. In some of these plants the flowers are all alike, and all tubular. In this group the pupils will find at this time of the year the Joe-Pye-weed, the ironweed, boneset, and golden-rod, with perhaps a belated thistle.

The Fall Composites.

In another group, the flowers in the centre are tubular, but those in the outer row have grown long and split open into the strap shape. In this group are the sunflowers, the asters, and the cosmos, while earlier in the year the daisy, the Black-eyed-Susan and the yarrow could have been added. In the last group all the flowers have become long and strap-shaped. Most members of this group bloom earlier in the year. The chicory flower, the wild lettuce, and the dandelion, will still be found, and perhaps an occasional belated hawkweed.

The Toad.

378. Much has been said in earlier sections (§ 143–153) concerning the toad. To set one on a table and let an ant creep near him will usually give us a splendid exhibition of his powers of marksmanship. But to really enjoy this fellow at his best one must know him out of doors. Beneath a lamp, especially an electric arc light on a pleasant summer night, a group of toads will often collect. If it is "June bug" season the pursuit and capture of this insect by the toad is a source of unending delight. The toad submits to capitvity very well, and thrives in the live-cage. He soon grows acquainted with those about him, and is comfortable and natural in their presence. He is apparently quite fond of having his back scratched.

The Grape

379. The grape is one of the fall fruits that illustrates very well the principles underlying fleshy fruits (§ 279). The skin keeps out smaller insects and especially bacteria and moulds. When it splits close to the stem, moulds almost immediately attack it. The blue color attracts the birds, for whom wild grapes seem intended. They eat the juicy pulp. The seeds are so hard and firm that they escape the grinding action of

the bird's gizzard (§ 282) and the solvent action of the intestine. Accordingly they are dropped at random everywhere and spring up into new vines. A certain kind of grape, properly dried, is the raisin.

380. The pupil has learned in an earlier lesson to read the thermometer (§ 357). Now it remains to understand the thermometer. Let a bottle with a slender neck be filled up to a point about half way up the neck with water as cool as is available. Now take a small rubber band and put it around this neck just at the level of the water so as to mark its height. If now the bottle is stood in a large vessel of warm water it will be noticed that as the water in the bottle gets warmer it gets larger and fills the bottle higher. It will sometimes be noticed that on first warming the bottle the water drops for a few seconds. This is because the bottle warmed and got larger before the water inside could get the heat. But the water soon catches up and then rises above the mark. The thermometer is a bottle with a very slender neck, filled with mercury part way up the neck. Review the methods of reading the thermometer and read the temperature of a number of locations. The metallic scale bearing the mercury can be slipped out of its tin case in many thermometers. This can be put in the arm-pit and covered by the clothing. If left here for five minutes it will about register the blood temperature.

The Thermometer.

381. The return of Christmas brings the cone trees once more into prominence. The pupils by this time are ready to try a little work in classifying, and the following table will serve to determine the commonest of our wild and cultivated members of this group:

Cone-bearing Trees.

KEY TO OUR COMMON CONE BEARERS.

I. Summer Green.
- **1. Leaves single .... Cypress.**
- **2. Leaves clustered .... Larch.**

II. Evergreen.
- **1. Leaves single.**
  - **A. Flat, oval, outstanding .... Box.**
  - **B. Flat, pressed to the stem .... Arbor Vitæ.**
  - **C. Awl-like, prickly pointed .... Juniper.**
  - **D. Needle-like.**
    - **a. With a leaf stem.**
      - ***a.* Spreading from stem in all directions .... Spruce.**
      - ***b.* Spreading from stem in two directions .... Hemlock.**
    - **b. With no leaf stem .... Fir.**
- **2. Leaves clustered—Pine.**
  - **A. In fives .... White Pine.**
  - **B. In threes .... Pitch Pine.**
  - **C. In twos .... Yellow Pine.**

WINTER TERM

382. The walnut is in striking contrast with the grape (§ 379) and is much like the hickory nut in its general activity (§ 363). While the nut is forming a pulp, distasteful in the extreme, protects the tender kernel. Later the shell hardens and the hull, now no longer necessary, loses its bad flavor. While the leaves were green the fruit concealed itself by being green also (§ 285). After the leaves dried up, and the nuts were to fall to the ground, they took the color of the earth and the dried leaves. Heavy as the shell is, the squirrel's long sharp teeth have vanquished it.

The Walnut.

383. Either a horse or a squirrel may be studied as opportunities offer. The horse (§ 196–198) has lost all

but the middle toe on each foot. Here the toe-nail has grown all around the toe to form the hoof. If we protect this from wear with a shoe, we must trim his nails when we change his shoes. Having no long pointed teeth to bite with, and no horns, he must take to kicking for defence. When he eats grass he moves his head just the reverse of the cow (§ 200) and chews it as he nips it, instead of chewing the cud. The squirrel has the typical rodent teeth (§ 203). His sharp claws let him catch hold of tree trunks well. His long tail serves somewhat like a bird's tail (§162) as a rudder in his long jumps. What does he eat? Is he about in winter? How many kinds of squirrels have you in your neighborhood?

The Horse or the Squirrel.

384. The chickadee is one of the most interesting of our winter visitors. He will be found with the downy woodpecker (§ 339) and the nuthatch (§ 361), but while they are seen chiefly cleaning the trunks of trees, he works especially on the small twigs. He is quite indifferent as to whether he is right side up or not. His beautiful black cap and his merry song, a quiet telling of his own name, will distinguish him. He sings "chicka-dee-dee-dee; chick-a-dee; chicka-dee; chick-a-dee-dee-dee-dee." When summer comes he starts for his mating and nesting summer home in the North.

The Chickadee.

385. The earlier study of the stars has made us acquainted with Orion (§ 344) and the Pleiades (§ 364). On a line drawn from the Belt of Orion to the Pleiades and nearer the latter lies a very bright star. This is the fiery eye of the Bull. It is at the left top of a V, the point of the letter being supposed to represent the nose of the Bull. The old eastern sages, of the valley of the Euphrates,

The Constellations of the Bull and the Dog.

looked upon these constellations and saw them, so far as the eye could distinguish, practically as we see them to-day. Coming out of its deep antiquity, the book of Job seems to acquire a nearness to our own day when the Almighty, speaking to Job and his companions, to prove his great power and their entire helplessness says:

> "Can'st thou bind the sweet influences of Pleiades,
> Or loose the bands of Orion?"

Two fairly bright stars north of Orion, in the prolongation of the arms of the V, are the tips of the horns. The Pleiades lie in the shoulder of the Bull. If there ever was any continuation of this animal he has faded away, and nothing but the front quarter and head are left. This is the Bull that carried Europa across the Hellespont. Directly opposite Orion from the Bull and equally far away is the brightest true star (the planets Jupiter and Venus are often brighter) in all the heavens, the Dog Star. This is the eye of the Dog, whose nose points rather toward Orion. He is sitting, and a triangle to the south of his eye marks his hind quarter, with his hind feet stretched in the direction towards which he faces. This group of three constellations may well stand out in the mind of the child, as he sees it winter after winter. In the centre is Orion, a club upraised in his right hand and brandished in the face of the charging Bull. The Dog, in cowardly fashion, sits behind Orion watching the fight.

It is of course clear that stars have no real relation to such things as dogs and bulls. Almost any other figure could be as clearly seen. The modern astronomer locates stars not by these devices, but by what is practically celestial latitude and longitude. In these times those old creations will not retain a hold much longer on the imaginative mind.

386. Shale and granite are two markedly different kinds of rocks and the pupils are now ready to see them. One is in layers, and shale may well stand for this type. Put a handful of earth into a bottle, and nearly fill the bottle with water. Cork it, shake the bottle thoroughly, and then allow the contents to settle. It will be noticed that the bigger and heavier fragments settle on the bottom, lighter particles higher up, and that a fine mud settles on top. So in the bays and along the shores of the continents the soil brought down by the rivers settles layer after layer. When these are covered up by the later layers and baked into rock by the heat of the interior of the earth, they form shales, slates, sandstones, and limestones. The layering can often be told in the small specimen as in the shale; but it is easier to see it in the rock itself. Granite, in the sense in which we will use it here, and in the sense in which it is commonly used when we speak of building materials, is rock which though perhaps once formed in this way has not only been baked stiff but has melted and become pasty; so that all small layer lines are completely gone. When these rocks cooled, they crystallized out in shining speckles.

Shale and Granite.

387. For the next study one should have a bar or horse-shoe magnet, together with a knitting-needle if possible, and if not, some steel nails. To this should be added about half a teaspoonful of iron filings if possible, and if not, a pack of the smallest obtainable tacks. Show that the magnet will lift the steel knitting-needle, the steel nails, the iron tacks, or the iron filings. Will it lift paper, wood, a penny (copper), a five-cent piece (nickel), a dime (silver)? Take the knitting-needle and using always the same leg or end of the magnet stroke the knitting-

The Magnet.

needle from end to end a dozen times, always beginning at the same end and always stroking in the same direction. Now see whether the knitting-needle is a magnet. Break the knitting-needle in half and try the halves. Are they magnets? Put a little piece of cork on each end of one of these half knitting-needles and float it in a china or glass basin. Which way does it point? Mark the end that points north with ink. Try the other half of the knitting-needle in the same way, and mark its north end. What could such a needle be used for? (The Chinese did this very long before we knew anything about the compass.) Now while one needle floats, hold near its marked end the marked end of the other half. What is the result? What happens when you hold the unmarked end to the marked? When the two unmarked ends come near together?

SPRING TERM

The Walnut or the Chestnut Tree.

388. The walnut tree is assigned here in the hope that the pupils will watch at the earliest leafing of the walnut for the beautiful slender bunches of flowers containing only stamens. Closer to the branches are the few short flowers that bear the pistils and will become the walnuts. The flowers of the walnut are so beautiful, and so very rarely seen by the ordinary observer, that it is well worth while to know them. The long slender stalks of staminate flowers of the chestnut are easily seen. Hunt farther back, or at the very bottom of these yellow stalks, for the minute green burrs, with their three pink tails, the stigmas, which will later be the tails of three chestnuts in the burr.

389. Make an aquarium as directed in a previous section (§ 58) or use a glass jar. From any pond or

stream gather water, a few stones, and a little sand, and a few plants that grow with their leaves under water. Clinging to the plants and stones you will find pond snails. Transfer these to your aquarium. Note their foot, head, mouth, and tentacles (§ 134). See them approach the surface occasionally and open a hole in the side of the body to get a bubble of air. Watch them eat; you can see the mouth working against the glass, if you use a hand lens. Even the naked eye will show much in a good light. Sometimes a snail will slowly walk across the under side of the top of the water (§ 134). It will not be long before little masses of jelly will be noticed clinging to the glass side of the aquarium or to the plants. These are the eggs (§ 134) of the pond snail, and each little yellow spot in the mass is to be a snail. Watch these under the hand lens and a most interesting series of occurrences will be observed. I think any observer will be struck when the forming snail first moves in the egg.

The Pond Snail.

390. Let the pupils draw the shape of the moon some evening soon after new moon. At the same time they should put a few of the brightest neighboring stars in their proper position with relation to the moon. Let this be repeated each night for a week. The change of the moon both in shape and in position will be easily apparent. An account of the features of the moon has been given earlier (§ 296), and will be suitable for study when the moon comes to the full.

The Moon's Motion and Its Surface.

391. An earlier section (§ 373) described a study of the breakfast table, and will serve as a model for this more extended exercise on the dinner table. The physiological basis of an elaborate dinner may perhaps

be added. The soup, which in a full dinner should be dainty, is intended to whet the appetite without in the slightest sense satisfying it. The meat and vegetables should furnish the substantial food. The dessert must be very tempting or we would not eat it, and should be light, for we have already well eaten. Coffee, if taken at the close, is like a whip to drive the stomach to work, especially when we have eaten too much.

The Dinner Table.

392. The Baltimore oriole is often known as the golden robin. His feathers are colored a beautiful orange and black. These were the colors of Lord Baltimore and to them the bird owes half of its name. The hanging nest (§ 181) of the oriole is one of the handsomest pieces of bird structure the children will ever meet. The rich voice, not unlike that of the robin but far fuller and more sonorous, makes it in a double sense the golden robin. This is one of our very useful insect-eating birds and should be encouraged in every way. Colonel Brown, the Indiana "bird and bee man," says (and he knows the oriole intimately) that if we will litter our lawns with pieces of string about eighteen inches long, while the apples are in blossom, we will be very likely to attract orioles and coax them to build near by. Be very careful not to disturb a nest by observing it too closely, or the birds will desert it.

The Baltimore Oriole.

393. The ground ivy is so common in the grass as to furnish a more than ordinarily good lesson. It creeps with its stem on the ground. This means the browsing animals might eat it but they can only eat the tip of the stem and it will soon grow up again. In addition, it has an aromatic juice that makes it objectionable eating to

The Ground Ivy.

most animals. It roots every here and there along its prostrate stem. Hence if it is tramped on and broken each half can still grow. The leaf-ends of the stem and its branches turn up and catch the sunlight. The purple flowers attract little bees and flies. The lower lip in each flower shows them where to light. Blue lines then indicate the direction to the stores of nectar. Meanwhile ants, who are too smooth to carry pollen from flower to flower, and who might rob the nectar, are kept out by bristles on the stem at the bottom of each pair of leaves. The square stem and the lipped flower, together with the aromatic odor of the bruised leaves, tell us this is a member of the great mint family.

XIX

HELPFUL BOOKS ON NATURE STUDY

394. The teacher of nature study, like the teacher of any other subject, will deny himself much if he does not go to the literature of the subject for help in his work. But there is an especial danger in such help on this subject. So soon as one takes to the book instead of to nature for questions that nature could easily answer, he loses the spirit of the work. One must be careful, therefore, to ask many questions of things themselves under the open sky, and to read with patience in nature's book. The best service any nature book can render is to send us out into the open better equipped to read nature's own story written in living letters on the broad face of field and meadow, of hill and valley, of stream and lake, of beach and ocean.

The Danger of Nature Books.

395. No attempt is made here at fullness. A few of the most easily accessible books, that seem to the author best adapted to the needs of the class of teachers for whom this book is written, are briefly characterized. It is no criticism of a book that it is not here mentioned.

This List is not Full.

396. Perhaps the most important single book thus far brought out to supply the needs of the nature-study teacher is Dr. Clifton F. Hodge's "Nature Study and Life," published by Ginn and Company. It is a mine of information and has the advantage of being written by one who is both teacher and scientist.

Hodge: "Nature Study and Life."

397. Mrs. L. L. W. Wilson, in her "Nature Study in Elementary Schools," published by the Macmillan Company, has given a detailed series of lessons, month by month. This author has a positive genius for finding materials for work in city schools. Where a more detailed program is wanted than preceding sections of the present book supply, Mrs. Wilson's book will be found of distinct advantage.

Wilson: "Nature Study in Elementary Schools."

398. The Nature Study department of Cornell University, under the splendid directorship of Professor Bailey, seconded by Mrs. Comstock and Mr. John Spencer and their enthusiastic helpers, has issued a series of unusually helpful leaflets. A considerable collection of these has been published by the Department of Agriculture of the State of New York under the title: "Cornell Nature-Study Leaflets." The sections of this book contain most excellent accounts of the subjects they discuss. From the nature of the collection it is fragmentary. But as suggestions toward the method of treating the subjects, rather than as sources of information, these leaflets are very helpful indeed.

The Cornell "Nature-Study Leaflets."

399. For the teacher who wishes to assure himself he is doing wisely in teaching this subject at all, and who is called upon to meet adverse criticism, I know of nothing better than Professor Bailey's "The Nature-Study Idea," published by Doubleday, Page and Company. It will help one to return with courage to work that is sometimes discouraging.

Bailey: "The Nature-Study Idea."

400. Besides owning at least one book on the general subject, the enthusiastic teacher will surely want one other, dealing with some section of the material.

It will be of distinct advantage if, as before suggested, each of several teachers will take a different department, with which he will make himself more particularly familiar. These teachers should then serve each other as authorities in their several departments. For the teacher who wishes to gain a broad conception of the animal world as the background for thoughtful nature work, a good modern text-book on general zoölogy is desirable. I think for this particular purpose I know of none better than "Animal Studies," by Jordan, Heath and Kellogg, published by D. Appleton and Company. Far less ambitious, but excellent so far as it goes, is the little book on "School Zoölogy," by M. Burnet, published by the American Book Company.

Jordan: "Animal Studies."

401. The one department in which the teacher will perhaps be most tempted to specialize is that of the birds. Fortunately one of the best of all the books the nature movement has brought out awaits one here. Mr. Frank Chapman's "Bird Life," published by D. Appleton and Company, is almost ideal. It is quite within the comprehension of the beginner, is scientific in its spirit, has a very workable field-key and has nothing in it that must later be unlearned.

Chapman: "Bird Life."

402. The class of animals which approaches nearest the birds in general interest and in availability for elementary work is that of the insects. Here, too, we have a good book by a capable scientist which is still not too technical for the general reader. This is "Insect Life," written by Professor John Comstock and published by D. Appleton and Company The insects are here grouped according to the nature of the situation in which they are most commonly

Comstock: "Insect Life."

found. This arrangement is quite a natural one in connection with our present purpose. For the butterflies Mrs. Comstock's book on "How to know the Butterflies," published by the Scribners, is admirable.

403. It is quite worth while that the spiders should have much more study than they have generally had. For this purpose "The Common Spiders of the United States," written by James H. Emmerton and published by Ginn and Company is the best book now on the market. I feel sure many teachers, if they would but enter on this field, would find it very attractive.

Emmerton: "Our Common Spiders."

404. Plants, while less interesting than animals, are more abundant and more easily gathered and kept. The result is that they often play the main part in nature-study work. It is very desirable that the teacher who has not had a good modern course in elementary botany should overcome his disadvantage by the careful reading of one of the number of recent text-books that have transformed that science. For the nature-study teacher one of the very best is Professor John Coulter's "Plant Studies," published by D. Appleton and Company.

Coulter: "Plant Studies."

405. In "A Few Familiar Flowers," published by Ginn and Company, Mrs. Morley has described in excellent spirit the spring plants that are most likely to be used by the teacher. No better work could be done by the beginner in the study of plant life than to parallel Mrs. Morley's account in work with other flowers.

Morley: "A Few Familiar Flowers."

406. The inexperienced student of plants who has not learned to use a key, or having learned has forgotten, will want a book by which to name the plants he finds or his pupils bring in. For this purpose an

excellent help is Mrs. Dana's (now Mrs. Parsons) "How to Know the Wild Flowers," published by Charles Scribner's Sons. The teacher who will tint with water colors the pictures of this book as he finds the flowers will give himself most interesting and profitable exercise in plant study.

Dana: "How to Know the Wild Flowers."

407. The ferns are so beautiful, and it is so easy to learn how to identify most of them, that they, too, will deserve the attention of the teacher. Transplanted into the school yard, if given a similarily moist and shady spot they thrive and do much to beautify the grounds. Mrs. Parsons' "How to Know the Ferns" serves here most thoroughly. It is published by Charles Scribner's Sons.

Parsons: "How to Know the Ferns."

408. No phase of plant work will prove more lastingly interesting than the study of the trees. Fortunately here, too, we have a most excellent book. Miss Julia Rogers' book entitled "Among Green Trees," published by Mumford and Company, pays so much more attention to the life of a plant than any of the other authors who treat this subject for the beginner, that her book is particularly strong from the nature-study side.

Rogers: "Among Green Trees."

409. The teacher who is attracted by the few lessons in this course on the soil, the rocks, and the weather, will find assistance in understanding this side of the subject from any of the excellent recent text-books on geology and on physical geography. Perhaps none is simpler for the untrained teacher than "The Earth and Its Story," by the late Professor Heilprin, and published by Silver, Burdett and Company.

Heilprin: "The Earth and Its Story."

410. Similarily the little work done here in a study of the sky may stir up some teachers to do more. To such a very excellent help will be found in Professor Garrett Serviss' book called "Astronomy with an Opera Glass," published by D. Appleton and Company.

Serviss: "Astronomy with an Opera Glass."

411. The teacher who grows really imbued with the spirit of the work will want to commune with the great spirits who have loved nature and told us of their love. Such a student should begin with any one of John Burroughs' nature books. If it is desired to purchase but one, "A Year in the Fields" is made up of selections from many others, put into the order of the seasons, and is published by Houghton, Mifflin and Company in very attractive form. Mr. Burroughs seems to me to have succeeded better than any other nature writer in describing with absolute simplicity the thing he sees.

Burroughs: "A Year in the Fields."

412. After Burroughs the nature lover will want to read Thoreau's writings. These are far more subjective than those of John Burroughs, the strange and interesting personality of the author standing out on every page. Here, again, if but one book can be purchased, it should certainly be "Walden."

Thoreau: "Walden."

413. The man who first taught the student of nature how much of interest can be found in one's own locality was Gilbert White, whose "Natural History of Selbourne" is a world-famed classic and most suggestive.

White: "The Natural History of Selbourne."

414. Still farther back in English literature lies a gem of the first water. Izaak Walton's "Compleat Angler" is an unending mine of delight to the sym-

pathetic lover of nature. It would have been a revelation to Izaak Walton to have seen the capture of a fine muskallunge, not to mention a tuna or a tarpon; but his naïve simplicity and his charming love of everything out of doors is most delightful.

Walton: "The Compleat Angler."

415. But the book of books on this subject remains to be mentioned. It is issued periodically with illustrations magnificently colored. The language is by turns simplicity itself and technical complexity, varied often by portions absolutely and bewilderingly obscure. But unending study brings unending reward, for the book is Nature herself, and its author is God.

The Book of Nature.

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